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‘An Extended PMBoK Project Management Model for Companies Delivering Large Multidiscipline Mining Projects.’

A thesis presented by:
Michael Edward Brian Yates
2005 11322
to the Faculty of:
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Postgraduate School of Engineering Management
fulfilling the requirements for the degree of
Doctor of Philosophy

University of Johannesburg
Johannesburg – South Africa

Supervisor: Professor Jan-Harm C Pretorius
Co-Supervisor: Doctor Annlizé L Marnewick
August 2017
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I also acknowledge the Senior Project Managers and Project Engineers of WorleyParsons RSA - MMC and the client groups who inspired this study, persevered through the interviews, provided honest criticism, encouragement and guidance.

I specifically acknowledge the learned support, robust academic guidance and encouragement of my sponsors Professor Jan-Harm Pretorius and Doctor Annlizé Marnewick of the University of Johannesburg.
Declaration

I Michael Edward Brian Yates declare that:

The thesis titled ‘An Extended PMBoK Project Management Model for Companies Delivering Large Multidiscipline Mining Projects.’ hereby submitted by me for the degree Doctor of Philosophy (D Phil) at the University of Johannesburg is my own work and has not previously been submitted by me at another academic institution. I furthermore cede copyright of this thesis in favour of the University of Johannesburg.

Signed: 

Michael Edward Brian Yates (2005 11322)
Abstract

The primary aim of this research is to identify some of the key differences between the first and third party approaches to project execution and by doing this identify how third party project delivery can be improved. The third party, Engineering, Procurement and Construction Management (EPCM) Company engaged by the mining client to deliver a large multidiscipline mining project does not benefit directly from the completion of the project other than being able to bill for hours worked and expenses incurred.

Though highly regarded and widely applied, the PMI PMBoK® Guide 2013 does not fully address the requirements of the EPCM Company. Thus the aim of this thesis is to examine on a broad basis this gap in the current research, review the challenges being faced by the EPCM Company delivering a large multidiscipline mining project, reflect on the key differences between the EPCM Company project perspective and the Client project perspective, examine some of the aspects that should be addressed to assure an execution legacy, create awareness of some of the techniques that can be developed and adopted to improve project execution performance, create project execution artefacts and generate improved alignment between the EPCM Company and the Client.

The basis of this examination was an extensive literature review from which a questionnaire was developed, and exhaustive interviews of experienced senior project personnel. From the analysis of the responses recommendations for best practise were developed and transposed into enhancements of the PMI PMBoK® Guide (2013) Project Management Model.

The result of this research is the recommendation that the EPCM Company should apply this extended and complementary project management model in order to give improved assurance of project success, to develop enhanced project management artefacts as a project execution legacy.

The thesis gives insight into areas of future research in this field.
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List of abbreviations

The following terms and abbreviation have been used in the text of this thesis:

ANSI: American National Standards Institute
APM: Agile Project Management
CBE: Control Budget Estimate
CPM: Critical Path Method
EPCM: Engineering, Procurement and Construction Management (third party)
GMP: Guaranteed Maximum Price
HR: Human Resources
ICT: Information and Communication Technology
ISO: International Standards Organisation
KM: Knowledge Management
MDI: Millennium Development International
MTM: Multiple Team Membership
NPD: New Product Development
NPV: Net Present Value
PM: Project Management
PMBoK®: Project Management Body of Knowledge
PMI: Project Management Institute
PMP: Project Management Professional
R&D: Research and Development
RBS: Risk Breakdown Structure
RFI: Request for Information
TCC: Target Cost Contract
TQM: Total Quality Management
WBS: Work Breakdown Structure

Where other terms and abbreviations appear in the text; these would be defined in the text where they appear.
## List of appendices

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Part 1 – Introduction to the study

Chapter 1: Introduction to and intent of the study

1.1 Thesis title

The title of this thesis is:

‘An Extended PMBoK Project Management Model for Companies Delivering Large Multidiscipline Mining Projects.’

1.2 Problem statement

Hassan, McCaffer and Thorpe (1999: 21) have reflected on the growing need for large scale engineering projects and the increasing complexity of these projects. Key aspects were identified then as being long duration, technically complex, using many disciplines and employing significant capital. Thus the large multidiscipline mining project execution environment is becoming more challenging and more complex. As these projects require the commitment of significant capital the client and the investors are asking for quicker returns on the investment and the application of newer technology for enhanced performance. Through scarcity of resources the EPCM Company project execution team is being sourced internationally, activities are being completed in dispersed regional offices, and the project execution sites are becoming more remote and strategically challenging.

In addition Whitty (2011: 526) reflects on the popularity and prevalence of project management as a field of study and the growth of project management practices in the working environment but paradoxically as he reflects projects continually run over their schedule and budget. Why then Whitty (2011) asks is project management ‘more popular than ever when so many fail’.

Noort and Adams (2006) and Flyvbjerg, Garbuio and Lovallo (2009) discuss huge spend in infrastructure development worldwide and that there is a poor record in the effective delivery of these projects. Flyvbjerg et al (2009) state that nine out of ten projects had cost overruns. Noort and Adams (2006) discuss the delays and cost blowouts on major construction projects, they state that historically mining projects have failed to deliver on the projections established in the feasibility study process. Thus there is a propensity for project failure in one or more significant aspects, so how can the EPCM Company engaged in the delivery of a large multidisciplinary mining project ensure that despite the outcome of the large multidiscipline mining project there are the residual artefacts of success remain upon the completion of the project?

Noort and Adams (2006) identified the following as being common problems; poor understanding of the mineral reserves, over optimistic mining rates, missing out key studies, over simplistic
modelling, perfunctory project time frames, poor leadership, poor cost control and a general failure to apply good project management skills such as detailed planning.

The importance of building a project execution legacy within the EPCM Company has not been identified and the importance to the EPCM Company of developing and entrenching knowledge management processes and key staff retention strategies has not been fully identified. EPCM Company success is not necessarily derived from the successful completion of the project deliverable for the client but is more likely to be derived from an enhanced reputation for successful and consistent project delivery, enhancement of EPCM Company personnel skills and an expanded knowledge and data resource.

Noort and Adams (2006) identified the significance of the project sponsor, project manager and the project customer in shaping the project. They identified the need for project specific procedures, a detailed project execution plan and the involvement of the EPCM Company. A key feature was the need to build an effective project delivery team from a dwindling pool of resources and the role that the peer review team can play when transitioning the project from one phase to the next.

It is presumed that an extended and enhanced set of project execution and management criteria are required for the EPCM Company.

1.2.1 Sub-problems

Arising from the main problem expounded above the following sub-problems are identified:

- The project execution complexity places inordinate demands on the EPCM Company for effective project delivery in the international environment that has not been fully determined. The complexity of managing multiple projects has not been identified and the importance to the EPCM Company of managing project complexity and uncertainty in the project execution strategy has not been identified.
- The fundamental differences between the Client and EPCM company perceptions of project success and failure has not been determined.
- The importance of being able to develop an agile and innovative approach to the management of large multidiscipline mining projects has not been determined.
- The benefits of ‘relational contracting’ with key contractors and partners in the delivery of large multidiscipline mining projects has not been determined and the challenges of budget estimating for large multidiscipline mining projects have not been fully identified.
- The importance of identifying and entrenching the tools for project safeguards and the tools for the minimising of ‘post project completion’ rework has not been determined.
1.3 Precepts

A precept is a rule or principle prescribing a particular course of action or conduct. The following new precepts are proposed for the conduct of EPCM activities in the large multidiscipline mining project environment:

- Establishing and utilising the new success criteria for the EPCM Company will enhance the project stakeholder’s ability to achieve net project success.
- Understanding the causes of project failure and the determination of broader holistic success criteria will assist the EPCM Company in determining the contributors to project success.
- Understanding and managing the sources of bias and asymmetry originating from the participating project stakeholders will improve project selection and execution through improving the return estimation, costing, risk identification, risk mitigation and project planning.
- Understanding, identifying and managing project complexity and uncertainty will improve project execution success.
- The acceptance and adoption of an agile, adaptive, and bespoke project management strategy will assist in the delivery of large multidiscipline mining projects.
- Developing cognitive, structured and embedded project safeguards will provide enhanced project success.
- The deliberate implementation of a focused relational contracting strategy will assist in project delivery through garnering greater key vendor support for successful project execution.

1.4 Objective of study

Though the adoption of the PMI PMBoK® Project Management Guidelines in the current 2013 fifth edition is widespread and gives criteria for project delivery it does not necessarily fully address the requirements of a third party EPCM Company delivering large multidiscipline mining projects for clients.

The EPCM Company would be called in by the client as a third party organisation to engineer, procure, and manage the construction of the project but the EPCM would not necessarily benefit directly from the completion of the project, other than being able to invoice for hours booked, fees and costs incurred. The client with an investor undertakes the project to enhance the client’s business with new products, additional capacity, maintained capacity or enhanced performance/efficiency and will thus benefit directly from the successful completion of the project.
It could be assumed that challenges faced by the EPCM Company intending to use resources and offices located internationally and deliver a project in a remote location would be exacerbated. The specific success criteria for the EPCM Company delivering large multidiscipline mining project should be examined and processes implemented to support these; this would benefit both the EPCM Company and the client.

The primary objective of this study is to develop an extended and enhanced PMI PMBoK® project management guidelines for the EPCM Company that will ensure the EPCM Company benefits from the project execution. The EPCM will have an enhanced pool of knowledge, integrated project execution teams and develop the project execution skills of the individuals.

A second objective of the research is to determine some of the causes of failure in large multidiscipline mining project delivery and to provide insight into these aspects so that the EPCM Company is in a position to pre-empt, and mitigate these aspects.

1.5 Intended contribution of this study

The intended contribution of this study to the academic ‘body of knowledge’ is to create a new paradigm in project execution particularly with regard to the management and execution of the large multidiscipline mining project when executed by an EPCM Company.

The intended contribution of this study to the project management ‘body of knowledge’ is to cause the identification of key differences in project execution processes and philosophy between the Client and the EPCM Company; this will be presented as proposed additions to the established PMI PMBoK® guidelines. In ascertaining these differences, it is intended that key success criteria for EPCM Companies will be identified to enable the EPCM Company to improve performance from the execution of projects on behalf of clients or users.

With the EPCM Company becoming more successful in the execution of projects it is hoped that the project execution will be more successful to the benefit of all the project stakeholders. In addition, the study will identify areas for further research in the arena of project management with particular reference to the third party project management companies.

It is envisaged that without research being carried in this area there is a risk that there will be a stagnation in the performance of ECPM companies. The value of the EPCM Company would not be in the collective experience of the EPCM Company but rather in the hiring in of the individual staff members.
1.6 Limitations

This study is limited to the scoping, execution and closure of large multidiscipline mining projects, the study excludes the tendering for this activity by the EPCM Company.

The interviews will be limited to one EPCM company involved in the execution of mining projects performed by and there will be a single client project manager interview. Due to the sensitive nature of project execution initiatives and project execution performance it will not be possible to interview personnel from other EPCM companies. The interviewees are all founded in a South African working office environment, though some of the projects and project experience will be in the International arena.

It is not in the scope of this study to test the recommendations on a project going into execution. The recommendations will be structured around PMI PMBoK® 2013 though there are other project management guidelines such as PRINCE 2 and ISO 21500 2012 that could be used as a basis for project execution guidelines.

1.7 Study methodology

This study used a participative research/ action research methodology. This method is followed to acquire valid primary data support for the precepts and to investigate the problem, was firstly reviewing the literature that determines and interprets the current project knowledge, followed by empirical or first-hand research to test the application and understanding of these theories with senior EPCM Company personnel.

Due to the profound nature of this study there are no published case studies reflecting current EPCM Company practices and their project performance. However, to give context to the study an extensive review of current mining literature was carried out, this provides a background to the nature and challenges of the mining industry, particularly in the broad international environment.

Interviews were carried out using a detailed, structured questionnaire based on the layout and the results of the literature study, the participant were encouraged to reflect on their own personal experiences rather than what would be seen to be best or desired practices. Leading experienced practitioners with the host EPCM Company were questioned on the aspects of the literature review that would identify and support the potential enhanced model.

1.7.1 Literature review

From Saunders, Lewis and Thornhill (2000) the literature review will be used to define and refine the research problem.

The literature review will be extensive and thorough and will be used to evaluate the literature in the field of study and also to define and refine the areas for the empirical research.
From Saunders et al (2000) the purpose of the literature review is to:

- Refine further the research questions and the objectives,
- Highlight research possibilities that have been overlooked implicitly in the research to date,
- Discover explicit recommendations for further research,
- Avoid work that has been done already,
- To sample current opinion to gain insight into research questions and objectives that are considered noteworthy,
- To discover and provide insight into research strategies.

The literature review endeavours to identify and analyse the current trends and research areas in project management, and to identify the key aspects affecting the performance of projects, in particular long duration and complex projects.

The following sources were consulted:

- Conference records,
- Books,
- Journal articles,
- Industry periodicals,
- Dissertations and theses.

The literature review forms a fundamental and integral part of the study. Previous research on the performance of projects is limited so the literature review was exhaustive and not limited to projects performed in the mining sector.

1.7.2 Empirical study

The empirical study is based on an analysis of the practical experience and observations of the interviewees. The foundation for the empirical study is a detailed questionnaire compiled to examine and develop the key issues identified in the literature and arranged into specific topics.

The interview questionnaire will be discussed in detail with eight experienced project managers and project engineers working for the host company and one client project manager. All of the interviewees were working on large multidiscipline mining projects in various senior capacities.

The responses are analysed in chapter six and the responses matched to the key aspects identified in the literature review. Analysis of the responses will make it possible to identify the levels of understanding of these aspects, the perceived relevance and identify new aspects to take forward into the recommendations.
1.7.3 Developing recommendations

Following the analysis of the interview responses the recommendations will be developed from the key or recurring issues identified in the analysis. Key issues highlighted by the literature review will be appraised and carried into the recommendation. The recommendations will be as an addition to the current PMI PMBoK® (2013) ten knowledge areas and process groups. There will be an appraisal of aspects of the study that could provide areas for future research.

1.8 Framework of study

The following sections describe the framework of this study.

The sequence of the chapters is illustrated below in figure 1.1:

![Figure 1.1 Sequence and layout of the chapters](image)

**Part 1: Introduction**

**Chapter 1: Introduction and intent of the study**

This chapter frames the intent of the study.

**Part 2: Literature review**

**Chapter 2: EPCM aspects of project management**
This chapter reviews the current project management knowledge areas and process groups as identified by PMI PMBoK® 2013. There is also a review of the literature relevant to the activities of the EPCM Company and the proposed additions to the project management model.

**Chapter 3: Client aspects of project management**

This chapter reviews literature relevant to the client and the EPCM Company interaction with the client and the proposed additions to the project management model.

**Chapter 4: Mining industry periodicals review**

Recent mining periodicals are reviewed for relevant case studies in the areas of complexity and uncertainty, International aspects, rescheduling – execution delays and expediting and budget cuts and capital scheduling; these are presented to provide the context for the interviews and the concluding chapters.

**Part 3: Empirical study**

**Chapter 5: Interviews**

This chapter describes the primary data collection process and the ethical considerations attached to this process.

Interviews will be conducted with experienced project managers and project engineering managers working for an EPCM Company, in addition there will be one interview with an experienced project manager from the Client group. A detailed questionnaire based on the key aspects of the literature review will used to determine the level of understanding of the new EPCM success principles identified during the literature review process. The interviews will also identify other areas of concern.

**Chapter 6: Analysis**

Empirical data presentation, interpretation and discussion.

This chapter provides an analysis of the empirical data obtained in the interviews in an overlay of the key aspects obtained from the literature reviews. The respondents’ opinions, understanding and experiences are captured and analysed to determine which project management aspects may be required or enhanced, to improve the EPCM legacy, project delivery performance and client relationships in the execution of large multidiscipline mining projects.

**Part 4: Conclusion of the study**

**Chapter 7: Recommendations**

In this chapter the outcomes of the literature review, the case reviews and the empirical data are compared to construct deductions, leading to findings and recommendations.
Chapter 8: Proposed PMBoK® model additions

The model described is a proposed additional set of project management tools or enhanced project management tools to improve the effectiveness of the EPCM Company in delivering large multidiscipline mining projects.

Chapter 9: Conclusion

The concluding comments describing the field covered and the results obtained in this study. This chapter also presents the contribution of this study to the body and presents areas for future work in this aspect of the field of the study.

Part 5: Appendices

Appendix 1

The two sections of the bibliography:

1.1 Bibliography: Literature Review.

1.2 Bibliography: Industry Review

The table 1.1 below illustrates the layout of the thesis.

Table 1.1 Layout of the study (Author Derived)

<table>
<thead>
<tr>
<th>Part</th>
<th>Aspect</th>
<th>Chapter</th>
<th>Page Number</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>Introduction</td>
<td>One</td>
<td>1</td>
<td>Introduction to the study.</td>
</tr>
<tr>
<td>Two</td>
<td>Literature review</td>
<td>Two</td>
<td>10</td>
<td>EPCM Aspects of Project Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Three</td>
<td>96</td>
<td>Client Aspects of Project Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Four</td>
<td>155</td>
<td>Review of industry periodicals to define the context</td>
</tr>
<tr>
<td>Three</td>
<td>Empirical study</td>
<td>Five</td>
<td>185</td>
<td>Interviews of host company senior project staff.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Six</td>
<td>232</td>
<td>Analysis of the interviews</td>
</tr>
<tr>
<td>Four</td>
<td>Conclusion</td>
<td>Seven</td>
<td>326</td>
<td>Recommendations for the proposed model revisions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eight</td>
<td>400</td>
<td>Proposed PMBoK® model additions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nine</td>
<td>427</td>
<td>Conclusion to the study</td>
</tr>
<tr>
<td>Five</td>
<td>Appendices</td>
<td></td>
<td>439</td>
<td>Bibliography</td>
</tr>
</tbody>
</table>
1.9 Conclusion

Chapter one covered the title, introduction to, intent, objectives, outcomes and benefits of the study.

Chapter two will commence with the detailed literature review for the study to establish the current understanding and research into project management, identify areas for possible incorporation in the proposed enhanced model and to identify areas for further research.
Part 2 – Literature review

Chapter 2: EPCM aspects of project management

2.1 Introduction

In this chapter there is a review of the PMI PMBoK\textsuperscript{®} 5th (2013) edition, in particular the process groups and knowledge areas. The PMI PMBoK\textsuperscript{®} ANSI standard provides a reference framework for the identification of novel aspects and additional criteria for project management particularly for the EPCM (third party) company as a study deliverable.

This chapter also contains an extensive review of literature discussing project management with respect to the activities of the EPCM Company engaged on large multidiscipline mining project delivery.

The key aspects from the literature review are developed in to a questionnaire so that the level of understanding and application can be established in the host EPCM company.

2.2 PMI – A guide to the project management body of knowledge (PMBoK\textsuperscript{®} Guide) 2013 ANSI/ PMI 08-001.2012

In this section there is a brief review of the PMI guide to the project management body of knowledge. This guide has become a common reference guideline for effective project management.

2.2.1 Definition of a project

The PMBoK\textsuperscript{®} Guide (2013: 4) defines a project as a temporary endeavour that is undertaken to create a unique product, service or result. Being temporary implies that there is a defined beginning and end to the endeavour but the duration is not defined. The end of the project is when the project has reached a conclusion, when the client determines that the project should come to an end or when it is identified that the projects objectives cannot be achieved.

The PMBoK\textsuperscript{®} Guide (2013: 4) continues the definition; every project will create a unique product service or result. Because of the unique nature of the project there may be uncertainties in the project delivery.

2.2.2 Definition of project management

The PMBoK\textsuperscript{®} Guide (2013: 5) defines project management as the use of knowledge, skills, tools and techniques to manage a project to achieve the project requirements.

PMBoK\textsuperscript{®} (2013: 5) identifies 47 project management processes which a clustered into 5 process groups.

PMBoK\textsuperscript{®} (2013: 5) defines the 5 project process groups as:

- Initiating, planning, executing, monitoring and controlling and closing.

PMBoK\textsuperscript{®} (2013: 5) identifies 10 knowledge areas:

- Project Integration Management
• Project Scope Management
• Project Time Management
• Project Cost Management
• Project Quality Management
• Project Human Resource Management
• Project Communications Management
• Project Risk Management
• Project Procurement Management
• Project Stakeholder Management

2.2.3 Comparative overview of project management and program management

PMI PMBoK® (2013) defines program management as:

‘A group of related projects, focussing on project interdependencies helping to determine the optimal approach for managing them through:

• Resolving resource constraints,
• Aligning organisational/ strategic direction,
• Resolving issues and change management within a shared governance structure.

The following table 2.1 demonstrates the key differences between project and program management:

Table 2.1 - Key differences between projects and programs: derived from PMBoK® (2013: 8)

<table>
<thead>
<tr>
<th>Organisational project management</th>
<th>Projects</th>
<th>Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope</strong></td>
<td>Projects have defined objectives. Scope is progressively elaborated throughout the project life cycle</td>
<td>Programs have a larger scope and provide more significant benefits</td>
</tr>
<tr>
<td><strong>Change</strong></td>
<td>Project managers expect change and implement processes to keep change managed and controlled.</td>
<td>Program managers expect change from both inside and outside the program and are prepared to manage it</td>
</tr>
<tr>
<td><strong>Planning</strong></td>
<td>Project managers progressively elaborate high level information into detailed plans throughout the project life cycle</td>
<td>Program managers develop the overall program plan and create high level plans to guide detailed planning at the component level</td>
</tr>
<tr>
<td><strong>Management</strong></td>
<td>Project managers manage the project team to meet the project objectives</td>
<td>Program managers manage the program staff and the project managers; they provide vision and overall leadership</td>
</tr>
</tbody>
</table>
Success is measured by the degree to which the program satisfies the need and benefits for which it was undertaken.

Program managers monitor the progress of the program components to ensure the overall goals, schedules, budget, and benefits of the program will be met.

### 2.2.4 PMI project manager responsibilities and skills

Responsibilities and competencies of the Project Manager are defined as:

- Knowledge,
- Performance,
- Personal,
- Leadership skills,
- Communication skills,
- Coaching,
- Trust Building,
- Team Building,
- Negotiation skills,
- Motivation,
- Influencing,
- Decision Making,
- Political and Cultural Awareness,
- Conflict Management.

### 2.2.5 Project environmental factors

PMBoK® (2013: 29) defines a series of environmental aspects that are out of the control of the project team but none the less affects the project team’s ability to deliver the project.

These factors include:

- Political climate,
- Government or industry standards,
- Geographic distribution of resources,
• Market place conditions,
• Company work authorisation systems,
• Project management information systems,
• Organisational culture,
• Personnel administration,
• Existing human resources,
• Commercial databases,
• Stakeholder risk tolerance.

2.2.6 Corporate knowledge bases – Organisational process assets

PMBoK® (2013) discusses processes and procedures for:

• Configuration management knowledge databases – standards, policies, procedures etc.,
• Financial databases,
• Historical information and lessons learnt knowledge bases,
• Issue and defect management databases,
• Process measurement databases,
• Project files from previous projects.

Defining aspects of project success:

• Completing the project within the constraints of scope, time, cost, quality, resources and risk.
• To ensure realisation of benefits for the undertaken project.
• Project success should be referred to the last baselines approved by the authorised stakeholders.

2.2.7 PMI knowledge areas PMBoK® (2013: 61)

PMI PMBoK® (2013: 61) expands on the knowledge areas as:

2.2.7.1 Integration management

Project integration management is a collection of processes and activities to identify, define, combine, unify and coordinate the activities within the project management process groups.

Incorporated in the project integration management the PMBoK® (2013) discusses the business case. This defines whether the project is viable from a business standpoint. The client project sponsor should agree the scope for the project and the limitations for the business case. From PMBoK® (2013) the business case for the project is triggered by one or more of the following conditions:
• A market demand for the product or more of the product,
• An organisational need to streamline the process or for other increased efficiencies,
• A request from a customer,
• A technological advance that should be captured,
• A legal requirement or a revised legal requirement,
• Ecological impacts or revised environmental requirements that need to be mitigated,
• Community or social needs.

2.2.7.2 Scope management
Project scope management are the processes required to ensure that the project includes the work required to ensure the project is completed successfully. Scope management is defining and controlling what is or not included in the project.

Project scope is defined by PMBoK® as the work to be performed to deliver the product or service. The requirements include the conditions or capabilities to be met by the completed project, the requirements have to be in sufficient detail to be captured in the scope baseline and provide a base for measurement.

From the project scope requirements, the WBS can be defined and developed.

2.2.7.3 Time management
Project time management includes the processes required to ensure the project is completed on schedule.

PMBoK® (2013) discusses in high level the use of an agile approach to project time management.

• Determining the current status of the work delivered against the work planned for the elapsed time,
• Reviewing the performance to date and instituting any improvements,
• Organising the backlog of tasks,
• Determining the time required for ‘deliverable’ completion,
• Managing the changes as they occur.

2.2.7.4 Cost management
Project cost management is the application of processes for the planning, estimating, development of budgets, financing, funding, managing and the controlling of costs so that the project can be completed within budget.

From PMBoK® (2013) comes the definition of schedule performance index (SPI) and cost performance index (CPI) as methods for measuring project status.

2.2.7.5 Quality management
Project quality management describes the processes and activities that determine the quality policies, objectives and responsibilities so that the project will meet the final requirements.
2.2.7.6 Human resource management
Project human resource management includes the processes that organise, manage and lead the project team. This also refers to the use of virtual teams and reflects on the challenges of managing and directing virtual teams.

2.2.7.7 Communications management
Project communication management refers to the processes for the timely and relevant planning, collection, creation, distribution, storage, retrieval, management, control, monitoring and the final disposition of project documentation.

2.2.7.8 Risk management
Project risk management includes the processes for conducting risk management planning, identification, analysis, response planning, and controlling risks on a project. Project risk management is executed to reinforce positive events and to minimise the likelihood and impact of negative events.

2.2.7.9 Procurement management
Project procurement includes the processes required to purchase or acquire the products, services or results needed from resources outside the project team. Project procurement management includes the contract management and change control processes.

2.2.7.10 Stakeholder management
Project stakeholder management includes the processes required to identify the people, groups or organisations that could impact or be impacted by the project. The processes have to analyse expectations, identify impact on the project, and develop appropriate management strategies for engaging stakeholders in project decisions and project execution. Stakeholder satisfaction should be managed as a project objective.

2.2.8 PMBoK® Guide sections
The following table 2.2 identifies the knowledge areas and defines the corresponding process groups in the PMBoK® Guide 5th Edition (2013) this will be developed in the closing chapters:

Table 2.2 - PMBoK® Guide sections: derived from PMBoK® (2013: 61)

<table>
<thead>
<tr>
<th>Knowledge areas</th>
<th>Project management process groups:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initiating</td>
</tr>
<tr>
<td>Integration management</td>
<td>Develop project charter</td>
</tr>
<tr>
<td>Scope management</td>
<td>Plan scope management</td>
</tr>
<tr>
<td></td>
<td>Collect requirements</td>
</tr>
<tr>
<td></td>
<td>Create WBS</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Knowledge areas</th>
<th>Project management process groups:</th>
<th>Initiating</th>
<th>Planning</th>
<th>Executing</th>
<th>Monitoring &amp; Controlling</th>
<th>Closing</th>
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<td></td>
<td></td>
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<tr>
<td>Time management</td>
<td></td>
<td>Plan schedule management</td>
<td>Define activities</td>
<td></td>
<td>Control schedule</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Define activities</td>
<td>Sequence activities</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Estimate activity resources</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Estimate activity durations</td>
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<td></td>
<td></td>
<td>Develop schedule</td>
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<tr>
<td>Cost management</td>
<td></td>
<td>Plan cost management</td>
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<td></td>
<td>Control costs</td>
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<tr>
<td></td>
<td></td>
<td>Plan cost management</td>
<td>Estimate costs</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Plan cost management</td>
<td>Determine budget</td>
<td></td>
<td></td>
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<tr>
<td>Quality management</td>
<td></td>
<td>Plan quality management</td>
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<td></td>
<td>Control quality</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Plan quality management</td>
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<tr>
<td>Human resource management</td>
<td></td>
<td>Plan HR Management</td>
<td>Acquire project team</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Plan HR Management</td>
<td>Develop project team</td>
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<td></td>
<td></td>
<td>Plan HR Management</td>
<td>Manage project team</td>
<td></td>
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<tr>
<td>Communication management</td>
<td></td>
<td>Plan Communication management</td>
<td>Manage Communication</td>
<td></td>
<td>Control Communication</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Plan Communication management</td>
<td>Manage Communication</td>
<td></td>
<td></td>
<td></td>
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<td>Risk management</td>
<td></td>
<td>Plan risk management</td>
<td>Identify risks</td>
<td></td>
<td>Control risks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plan risk management</td>
<td>Identify risks</td>
<td></td>
<td>Control risks</td>
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<tr>
<td></td>
<td></td>
<td>Perform qualitative risk analysis</td>
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<tr>
<td></td>
<td></td>
<td>Perform quantitative risk analysis</td>
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<tr>
<td></td>
<td></td>
<td>Plan risk responses</td>
<td></td>
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<tr>
<td>Procurement management</td>
<td></td>
<td>Plan procurement management</td>
<td>Conduct procurement</td>
<td></td>
<td>Control procurements</td>
<td>Close procurements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plan procurement management</td>
<td>Conduct procurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholder management</td>
<td></td>
<td>Identify stakeholders</td>
<td>Plan stakeholder management</td>
<td></td>
<td>Manage stakeholder engagement</td>
<td>Control stakeholder management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify stakeholders</td>
<td>Plan stakeholder management</td>
<td></td>
<td>Manage stakeholder engagement</td>
<td>Control stakeholder management</td>
</tr>
</tbody>
</table>

2.3 PMI PMBoK® Guide Construction Extension (2016)

In 2002 PMI started publishing industry specific guides to the project management body of knowledge. The 2016 construction extension describes the supplementary knowledge areas and
practices that are accepted as good practices on construction projects. This specific extension is reviewed here.

2.3.1 Construction project environment

The PMBoK® Guide Construction Extension (2016: 9) describes the project environment and the differences between the generic project life cycle. This is particularly with respect to the project scope, the number of stakeholders, the project risk, the regulatory environment and the contracting strategy. The guide describes the enterprise environment factors such as the site location factors, describing the local stakeholders and the geographical factors affected by the location of the site.

2.3.2 Construction project management overview

The PMBoK® Guide Construction Extension (2016: 19) introduces two additional knowledge areas, specifically:

- Project health, safety, security, and environmental management and,
- Project financial management.

2.3.3 Construction integration management

The PMBoK® Guide Construction Extension (2016: 29) identifies the key aspects of project integration management that apply to the construction project. These include the need for the project, the project financing, the expertise to be provided by the client organisation, the impact of the project on the existing organisation and the most suitable project delivery model. Critical to the success of the project would be the communication management and the process of making decisions in good time. The PMBoK® Guide Construction Extension (2016) develops the term value engineering, value engineering anchors the lowest life cycle cost whilst maintaining quality, safety and reliability.

In project execution the requirements for administration are expanded to include; dispute resolution, design clarification, change order management/ resolution and progress payment approvals.

2.3.4 Construction scope management

The PMBoK® Guide Construction Extension (2016: 45) identifies some of the key differentiators applicable to the construction project. The contract becomes the primary scope definer for the construction project. There is also a reduced requirement for a work breakdown structure in some of the repetitive construction projects. For scope clarification the PMBoK® Guide Construction Extension (2016) identifies the RFI or Request for Information document, and discusses the aspects of scope creep and change management.
2.3.5 Construction schedule management
The PMBoK® Guide Construction Extension (2016: 51) discusses the complexity of project schedule management in construction projects. There is a discussion of the number of activities, the activity relationships, and the impact of weather conditions. The initial planning should be in line with the contract requirements and be cascaded down to the contractors schedules, procurement schedules, subcontractors, look ahead and weekly planning.

2.3.6 Construction cost management
The PMBoK® Guide Construction Extension (2016: 63) discusses the aspects of cost management that are related to the construction project. Some additional costs that should be considered for the construction project include the aspects of weather, working hour restrictions, proximity to services, material logistics, labour resource constraints and site conditions.

2.3.7 Construction quality management
The PMBoK® Guide Construction Extension (2016: 73) identifies those quality or compliance requirements that are particular to the construction project and the quality controls that would be in place in a construction project. These would include the legislated quality requirements and any industry specific quality requirements. The principle controlling document on a construction site would be the project quality plan.

2.3.8 Construction resource management
The PMBoK® Guide Construction Extension (2016: 81) acknowledges the key role that resources play in the construction project. The resources includes the application of human resources, machinery, tools, permanent and temporary plant, material, consumables and energy.

2.3.9 Construction communications management
The PMBoK® Guide Construction Extension (2016: 89) acknowledges the greater importance of communication in the construction project. The stakeholder group for the construction project would include the site based project team and the site based contractors including their casual labourers. The construction project communication strategy would have to provide for change orders, daily reports on field activities and conditions, and provide for corporate social responsibility reporting.

2.3.10 Construction risk management
The PMBoK® Guide Construction Extension (2016: 99) presents additional aspects for managing construction risks. The uncertainties with the construction project would include the following; long durations, complex processes, unskilled labour, material supply constraints, work in the public interest, cost escalation and changing regulatory environment. The PMBoK® Guide Construction
Extension (2016) gives some consideration to risk management in the international environment and the types of insurance to be applied to the residual risks.

2.3.11 Construction procurement management

The PMBoK® Guide Construction Extension (2016: 113) discusses the complexity of the buyer/seller relationships on a construction project. On a typical construction project there could be many hundreds of contractor, subcontractor and material supplier relationships. The complexity of these relationships are made more complex by the procurement model to be employed and the degree of risk that the owner is willing to take.

In undertaking the procurement the owner or the owner representative would decide on the type of bond, insurances and inspections to be undertaken, the integration with other construction activities and the project delivery method to be followed.

In addition to the above the execution of the construction project procurement would require the management of scopes of work, statements of requirements, requests for quotations and or proposals.

The procurement process on the construction project also includes the management of the suppliers or contractors through contract administration, performance management, inspections, progress payments and managing claims.

At the closure of the procurement activity on a construction project the contractor may be required to submit such items as warranty documentation, manuals, training material, inspection reports, test data and as built documentation.

2.3.12 Construction stakeholder management

The PMBoK® Guide Construction Extension (2016: 135) identifies some of the key stakeholders common to construction projects. The broader stakeholder group includes the finance houses, lawyers and legal advisors, insurance companies, equipment suppliers, owners of proprietary technologies, regulators, technical consultants and labour agencies.

2.3.13 Construction health, safety, security and environmental management

The PMBoK® Guide Construction Extension (2016: 143) covers specifically the health, safety, security and environmental aspects of the construction project. This is not covered by the PMBoK® Guide but is a critical aspect of construction project management. The requirements for health, safety, security and environmental management are often prescribed by mandated local or regional regulations, the owner or sponsor and even by the financier. The project will often have to supply safety metrics as part of the reporting of the project performance.
2.3.14 Construction financial management

The PMBoK® Guide Construction Extension (2016: 159) covers specifically the financial management aspects of construction project management. The construction extension acknowledges that financial management is a skill required on the construction site. There is also the start-up costs of some contractors requiring initial capital to establish site.

The PMBoK® Guide Construction Extension (2016) also examines the source of funding for construction projects, contractor funded projects, project financial audits and project accounting systems.

2.3.15 Construction Extension concluding comments

The PMBoK® Guide Construction Extension (2016) highlights some of the project management aspects that are particular to the construction site. The extension added significantly the aspects of health, safety, security, environment and financial management which can significantly challenge the site teams.

2.4 Project leadership

Fundamental to the successful initiation, running and closure of a project is the selection of a good leader or leadership group. Various authors have discussed the difficulty and challenges of selecting the correct person(s) for this role. Should the individual(s) be a generalist or a specialist, should the ability be leading from the front or the back, which of the leadership paradigms should be followed, when should the leadership practice be changed? The leader’s role is to energise and empower the team, manage the client interfaces and manage the office politics.

Curran, Niedergassel, Picker and Leker (2009: 458) discuss the topic of personal aspects, particularly on the project leadership aspect. The authors’ primary area of interest is in the Chemistry and Pharmacy business.

The findings of Curren et al (2009) was that the stronger project leader requirement is highly dependent on the level of trust among team members and the administrative activity. The risk associated with a cooperative project and the extent of senior management support are not related to a stronger project leader. Often in the rush into the project ‘executables’ there is an disregard to the expectations from the leader.

Curren et al (2009: 460) in discussing the background to their study, ‘companies need to improve their innovation ability for growth and profitability’. They found that few firms showed organisational capacity for generating true innovations. Curren et al (2009) found that the degree of bureaucracy had a significant influence on the need for a stronger project leader.
This would be particularly relevant for the project manager in the bureaucratic environment of the large international EPCM Company managing the project for a significant mining house. Thus Curren et al (2009: 464) derived the following criteria for the evaluation of the project leader:

- Amount of administrative activity,
- Difficulty of project leadership,
- Management support,
- Risk of being treated unfairly,
- Trustful relationship.

Curren et al (2009: 465) also suggested that they could show that the requirement for a stronger project leader is dependent on the degree of trust among team members and the administrative activity. They could not demonstrate that projects that were perceived to be comparatively difficult to lead required a strong leader.

As a counter point Odusami (2002: 61) discussed the perceptions of significant role players in the construction industry with regard to the skills of an effective project leader. Odusami (2002: 61) evaluated the three most important skills of the effective project leader, these were; technical skill, human/social skill and conceptual skill.

Technical skill, according to Odusami (2002) is defined as an understanding of, and proficiency in a special kind of activity, involving particularly methods, processes, procedures, or techniques. To Odusami (2002) social skill is an ability to work effectively as a group member and to build cooperation within the team.

Finally, according to Odusami (2002), the conceptual skill, is the ability of a leader to see the enterprise as a whole and recognise how the various functions of the organisation interact and how changes in on part affect the other. Odusami (2002) reflected on the ten essential skills of the project manager; team building, leadership, conflict resolution, technical, planning, organisation, entrepreneurship, administration, managerial support building, resourcing.

Though there is little to be gained from this list that is new and of significant value it is essential to reinforce these attributes and perhaps add a few additional skills as appropriate for the complex economic and technical environment of the long term mining project.

Chan and Chan (2005: 413) evaluated the transformational and transactional leadership styles among building professionals in the construction industry. The main objectives of their study were; to examine the extent of leaders who are perceived to use transformational and transactional leadership styles, to identify which of the two leadership styles is best able to predict outcomes of leader effectiveness, extra effort by employees, and employees satisfaction with the leaders and to offer insight into the management theory for building professionals in business organisations.
Chan and Chan (2005) suggested that all five of the transformational factors and three of the transactional factors are significantly correlated with leadership outcomes of leader effectiveness; extra effort by employees, and employee’s satisfaction. Their results further supported that transformational leadership could augment transactional leadership in producing greater amounts of performance and satisfaction. Chan and Chan (2005: 413) state that ‘since the age of the industrial revolution, the role of professional employees has taken on tremendous importance. Society today has become very dependent on specialised expertise and knowledge; hence the increasing numbers of professionals and professional associations’. As the complexity of business increases so does the demand for professionals.

Chan and Chan (2005: 413) continue, ‘in the construction industry, the building profession has played an indispensable role that determines the performance of the industry. One of the most important research areas receiving relatively little attention in the construction industry is leadership.’

In conclusion Chan and Chan (2005) summarised their findings as follows:

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<th>Even though transformational and transactional leadership are exhibited building professionals use transformational leadership more frequently than transactional leadership in their work.</th>
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<tr>
<td>With transformational leadership, the most prominent behaviour used is inspirational motivation, followed by idealised attributes, intellectual stimulation, idealised behaviours, and individualised consideration.</td>
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<tr>
<td>Under transactional leadership, the most prominent behaviour used is contingent reward, followed by management-by exception (active), and management-by-exception (passive).</td>
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<tr>
<td>Transformational leadership and transactional leadership are complementary to each other. Transformational leadership can augment transactional leadership to produce greater synergistic effects on the employees’ work outcomes than either transformational or transactional leadership in isolation. However, transactional leadership cannot augment transformational leadership to the same extent.</td>
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The study of Chan and Chan (2005) enhances our understanding of the complexities involved in the project relationships, between leadership styles and employee work outcomes among building professionals in the construction industry. This could be transposed into the complexities of the mining industry.

Limsila and Ogunlana (2007: 164) examined the associations between the leadership style and the commitment of subordinates. In long duration projects, it is essential to develop robust and resilient teams, the saying that the team is bigger than the sum of its parts is particularly relevant in the long duration large multidiscipline mining project environment.

The study of Limsila and Ogunlana (2007: 164) highlights the association between leadership styles and the and work performance of subordinates. The study highlights to project managers that ‘their leadership style can enhance subordinates’ commitment, positive work performance, and develop a positive working atmosphere’. It would seem that they are searching for the ideal
leadership style to promote the best in work performance through creating a positive working environment. Limsila and Ogunlana (2007: 164) identified that a transformational leadership style over a transactional style had a positive association with work performance and the workplace commitment of subordinates. They also noted a positive effect on the leader performance.

Limsila and Ogunlana (2007) stated that effective leadership is essential for good project performance, there are projects that are facing problems in execution and often the root cause of the project problems can be traced back to poor leadership. This is obviously a broad statement as leadership has many facets that have to be managed effectively, and that the leadership style may need to change during the execution of the project, with changes in the project environment.

According to Limsila and Ogunlana (2007: 165) leadership research was gaining importance in construction management since it can have a positive effect on work performance and impact project outcomes. The leadership approach can shape staff performance in a positive way and facilitate construction trouble free projects. In addition, adopting suitable leadership approach will create subordinate satisfaction.

Limsila and Ogunlana (2007: 166) described the two well-known principle leadership styles:

<table>
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<tr>
<th>Transactional style</th>
<th>Transformational style</th>
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<tr>
<td><strong>Transactional style.</strong> Transactional leaders focus mainly on the physical and the security needs of subordinates. The relationship that evolves between the leader and the follower is based on bargaining exchange or reward systems.</td>
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<td><strong>Transformational style.</strong> Transformational leader encourages subordinates to put in extra effort and to go beyond what they (subordinates) expected before. The subordinates of transformational leaders feel trust, admiration, loyalty, and respect toward leaders and are motivated to perform extra-role behaviours.</td>
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Agreeing with Chan and Chan (2005), Limsila and Ogunlana (2007: 180) concluded with the statement, ‘the transformational leadership style has significant relationships with work quality, work quantity, and creativity in problem solving of subordinates’. In addition the transformational leadership style is better suited to the management of engineering personnel and is closely linked to the objectives of the project manager and the achievement of the project objectives.

There would be scope for performing a similar study in the large multidiscipline mining project environment and reviewing the responses for differing job categories with in the target environment.

Liu, Fellows and Fang (2003) discuss the concept of project leadership and the distribution of power amongst individuals on the project. According to Liu et al (2003) leadership styles are closely associated with power distribution and the exercise of power. Their paper develops a model of project leadership, referring their approach to construction projects and concludes by stressing the motivational function of good leadership through managing power gaps by means of power-sharing and power-gathering.
Liu et al (2003: 819) state that the ‘realisation of construction projects requires integration of inputs from many, often diverse functions and disciplines’. Specialisation increases the complexity of such integration and International socio-cultural differences exacerbate the difficulties. ‘Solutions are sought through endeavours to control, via legal–contractual means, formal organisational structuring and selection of participant organisations and their particular personnel’.

Liu et al (2003: 824) highlight in their text that power sharing and empowerment, as opposed to a Machiavellian approach is preferred for modern project management. Clearly the implementation of team empowerment has benefits in managing large multidiscipline mining projects. According to Liu et al (2003) the empowering leaders share a strong underlying belief in their subordinates’ abilities, as in the renowned McGregor (1960) Theory ‘Y’ argument. Overly bureaucratic environments are known to create conditions of powerlessness and, an authoritarian management style can strip away subordinates’ discretion and, in turn, sense of power. As such, certain leadership styles have a stronger bearing on the subordinates’ sense of powerlessness.

Liu et al (2003: 827) state that ‘In construction, as in other project situations, where differentiation is extensive, expertise (both special knowledge and experience) is an important source of power’. Liu et al (2003: 827) continue ‘hence, a heavy burden is placed on those charged with (the) integrating roles unless sufficient power accrues to them to question inputs from those specialists which the integrator (project leader) believes to be inappropriate, if only from an integrative/ coordinating perspective’. Liu et al (2003: 827) state ‘thus, the (expert) power vested in the integrator (project leader) is of paramount importance, given that a majority of problems in the realisation of construction projects are due to missing, incorrect or un-coordinated information’.

According to Rudolph and Peluchette (1993) certain leaders may feel threatened by an empowered subordinate or an empowered group of subordinates because there is some loss of control and, hence, will not contemplate power sharing. On the other hand, not all subordinates want to be empowered. For instance, it may be difficult to empower non-assertive individuals or individuals who cannot accept responsibility – ‘it is not my fault’ syndrome. As quoted, Block (1987) asserts, ‘blame avoidance is characteristic of the bureaucratic mind-set, while innovative individuals have no difficulty accepting responsibility without being immobilised by fear or guilt’. Walker (1989: 143) quotes Lao-tse, ‘to lead people, walk behind them,’ and continues, ‘As for the best leaders, the people do not notice their existence, the next best - the people honour and praise, the next - the people fear, and the next - the people hate. When the best leader’s work is done, the people say, “We did it ourselves”’. Walker’s extract from ancient Chinese Taoist philosophy confirms the motivational function of good leadership but also implicitly, ‘the leader’s realisation and manipulation of the power gap. That holistic approach of the Chinese yin-yang dichotomy is exemplified in maintenance-oriented and performance-oriented leadership, one does not exist without the other and together they imply unity.’
Liu and Fang (2006: 497) state that ‘The concept of leadership relates to power structuring whereby the project leader may lead and motivate through power disposition. Power, in its diverse guises, combines interpersonal and structural elements and can be enhanced through political manoeuvring. Power may also be distributed unevenly between individuals in the project team’. To Liu and Fang (2006: 497) project management requires attention to both the hard and soft systems, the formal system of rules and procedures and the informal or human system of motivation and leadership in order to achieve a successful project. Only the formal elements of organisational systems can be imposed, staff rely on these should the informal system fail. ‘Thus, formal contracts are, in part, designed to regulate power disposition of the parties and indicate procedures for the solution of conflict’.

Zavadskas, Turskis, Tamošaitienė and Marina (2008: 462) reflect that the number of construction projects has been growing rapidly and that companies have to manage rapid transformation in the competitive business environment. Quoting directly from Zavadskas et al (2008: 462) ‘Projects are collective, purposeful activities based upon the development of common understandings and interpretations of means and ends. They generate the personal and group knowledge contributing to their own success.’

Different projects may require different project managers and similarly one project manager may not have the capacity or ability to take one large multidiscipline mining project from inception to completion.

Linking to risk to project management Thamhain (2013) discussed the impact of team leadership in the risk mediation process. They introduce an association between adept risk management and the selection of the project manager. Thamhain (2013) expands the project leadership by reflecting on uncertainty as the main management challenge for most projects. This is particularly true for complex engineering projects, with a variety of technology and, dependent on innovation and experimentation. These conditions contribute to the risk and uncertainty, affecting managerial control and its intended results. The project manager must be in a position to examine the uncertainty in the project; this requires a more complex risk assessment process that has a shared understanding of the risk factors in the project.

In conclusion Thamhain (2013) discussed the contingent management factors in the complex project environment; a thorough understanding the project work, organisation processes, tools and techniques, and an effective project management platform. Contra-indicators include:

- Conflict and disagreements over personal or project issues,
- Insufficient sponsor involvement,
- Poor or lacking subject expertise,
- Weak change-management plans or updates,
- Performance measurement problems,
• Unclear or ill-defined deliverables and objectives,
• Underfunding.

Examining the emerging virtual project environment Mugunda and Pillay (2013: 457) linked ‘leadership effectiveness to asynchronous virtual project environment usage and communication’. They linked three leadership styles; ‘charismatic, virtual and transactional’ to two forms of leadership; participative and shared. Mugunda and Pillay (2013) identified that there is a need to elevate the confidence of the team and a need to minimise conflicts, decentralise the control and maximise the sharing within the project team. The authors named this ‘decentralised team leadership’. The effective management of the project in this environment according to the authors is contingent on the effectiveness of the communication, human resources, integration and scope. Mugunda and Pillay (2013) say that projects are more frequently being managed in the virtual project environment, this has placed a different emphasis on project leadership skills particularly with the asynchronous nature of the communication. Mugunda and Pillay (2013: 474) state ‘findings demonstrated that a virtual environment may require call for different leadership, power and politics for influencing the form interactions required for collaborative work. This is particularly relevant where there is a high power distance as in Africa. This calls for the combination of forms of power (such reward, legitimate and expert) and values related to politics (coalition building) leading towards enhancing trust and communication’. Mugunda and Pillay (2013) also reflect on the need for decentralised leadership building a shared vision and encouraging ownership, learning and sharing.

This section reflects on the wide variety of management skills, techniques and knowledge required of the project leadership and the skills required to monitor the performance of the project, picking up on the signals that would indicate a project that is in control and one that is going out of control. The selection of the project manager is important for the success of the project. In addition to this the working environment of the EPCM company will directly affect the workload of the project teams and this will also have an effect on the team morale.

2.5 Project human resources and knowledge management

The project manager is required to establish and deploy the project human resource and through the project team the retained knowledge of the EPCM Company. In the EPCM Company human resources, knowledge management and training are interrelated. Although knowledge can be recorded and documented, a certain volume of information and experience will not and cannot be documented and will be resident as tacit knowledge in the human resource.

As carefully as the EPCM Company will attempt to capture the knowledge into a recorded and documented form either this will not be complete or will be guarded, seen as being insignificant or
retained for personal security. With the increasing reliance on the internet, clouds and electronic communication, improvements in reliability and speed has developed the virtual office and the virtual team. This has improved the efficiency of resource utilisation and the ability of key resources to be allocated internationally. The virtual project team will be discussed separately.

Haas (2006: 1170) discusses the broader aspect of the project team and knowledge gathering, Haas states, ‘Knowledge gathering can create problems as well as benefits for project teams in work environments characterised by overload, ambiguity, and politics. More knowledge gathering helped teams to perform more effectively under favourable conditions but hurt performance under conditions that limited their capabilities to utilise that knowledge successfully’. There are benefits and challenges to knowledge gathering in the EPCM environment.

According to Haas (2006: 1170) most project teams are at the leading edge of their technology and are constantly seeking affirmation of their tasks as performed and should be constantly challenging their environment, ‘Knowledge-intensive organisations ranging from consulting firms to technology companies have invested substantial resources in “knowledge management” initiatives intended to facilitate these interactions, typically by installing information systems such as document databases or promoting forums that encourage interpersonal contact such as communities of practice’. Haas (2006) realises that in a challenging work environment there may be resultant difficulties in ‘Knowledge Gathering’. If knowledge gathering is seen as being of prime importance to the company then and as Haas (2006: 1170) states, ‘project teams can benefit more from knowledge gathering in challenging work environments if they have greater processing, sense-making, and buffering capabilities. These capabilities are important in any organisational context, but they are especially critical for addressing the problems of knowledge gathering created by overload, ambiguity, and politics’. Overload, ambiguity, politics and conflict will be seen to be prevalent in large multidiscipline mining projects.

For Haas (2006: 1181), ‘the benefits of knowledge gathering in challenging work environments depended on whether teams work under conditions that enhance or limit their capabilities to utilise this knowledge successfully. In a knowledge-intensive setting characterised by overload, ambiguity, and politics, project teams benefited more from external knowledge gathering if they had more slack time, organisational experience, and decision-making autonomy. Teams lacking these capability-enhancing conditions could actually harm their performance by gathering more knowledge’. Haas (2006) reviews the findings and states that the conditions under which the project is executed have a significant effect on the ability of the team to gather knowledge without detriment to the project.

It is of significant importance to ensure that the execution environment of the project is managed to ensure the project execution team can effectively benefit from the project experience. It is also necessary to provide time and the environment for the team to process, make sense and to provide a buffer to facilitate knowledge assimilation. Project teams working in an overload condition with
ambiguity and organisational pressure would experience underperformance through the incorporation of more knowledge.

Haas (2006) acknowledges the need for informal knowledge sharing but says that this should take place within a formal organisation structure. Haas (2006: 1182) concludes with the following statement, ‘Paradoxically, knowledge-gathering efforts that should help such teams to perform more effectively can hurt instead. Whether knowledge gathering ultimately is beneficial may depend less on the knowledge management architecture of the organisation than on the capabilities of teams to utilise the knowledge available to them to improve their performance’.

Clark and Colling (2003: 178) examine the impact of project management systems on human resources management. Clearly the effective execution of any project relies on the significant engagement of the personnel involved in the execution of the project. Clark and Colling (2003) discussed the lack of alignment between project management literatures and human resource literatures when it is likely that management systems are key for the deployment of staff in an EPCM company. For Clark and Colling (2003) project management is a core mechanism for many organisations along with the deployment of human resources, particularly so in multinational firms. They continue by stating that project management techniques are becoming increasingly prevalent, they focus on the operational impact of project management in engineering activities and the practical implications of this for those involved in the management of human resources. It is reasonable to think that the project management team will be as temporary as the project that it supports, it is therefore necessary to ensure the project team is well selected and grounded as quickly and as effectively as possible to minimise start-up lag and disruptions.

For Clark and Colling (2003), ‘Project management refers to the creation of a group of individual specialists from different parts of the organisation that are brought together for a limited period of time to contribute towards a specific project’ and as soon as the project is complete the group is disbanded and assigned to new projects, the project management teams operate as an overlay of departments in matrix organisations. Clark and Colling (2003: 179) discuss the coordination and development of the project teams in that project management systems coordinate skilled employees in a project-focused yet supportive framework. ‘Hence project management systems span the spectrum of control and consent’. Either the systems can direct and control or they can be high level and engender trust. Clark and Colling (2003) examine the evolution of the human resource effort in the organisation where the key asset of the organisation and the key competitive advantage is the human resource, this is particularly relevant for the EPCM Company. In knowledge-based companies where employees are the basis of a firm’s competitive advantage it is necessary for the HR function to enable and support the capability within a project management environment through the application of appropriate policies for recruitment, selection, appraisal, development and reward.
This alludes to some of the problems due to the disconnect between the human resource personnel and the project management personnel, project success is very dependent on the effectiveness of the human resource.

Clark and Colling (2003) conducted a survey of two engineering services companies and give the following points. ‘Professional engineers control project management and the provision of engineering services. They and the operating procedures within which they work are the bases of competitive advantage and these procedures are robustly defended through an embedded engineering culture’. For Clark and Colling (2003: 183) there is doubt in the engineering fraternity when dealing with the controls of other functional areas in the organisation. They state, ‘The engineering culture creates clarity of mission where engineers formulate project design and specify appropriate technologies with complete autonomy from technical controls formulated by functional areas of management such as finance or human resources’.

How can this be addressed and a cooperative process of managing the engineering resource in a company be established? Clark and Colling (2003: 183) state, ‘Engineering expertise and identities dominate professional management in both firms whereas project management represents the core system that organises and realises the expertise and skill of professional management in this sector. The highly distinctive sector-driven approaches to project management and associated systems of staff development and training reported on have a considerable impact on the HR function and efforts to improve and become involved in the project management process’. Clark and Colling (2003: 189) state that, ‘To appreciate the divergent views of professional engineers and HR specialists rests on recognising that for many engineers an established pattern of project management is the competitive advantage of each firm and is not a constraint on efficiency or efforts by the HR function to standardise revise and reform specific aspects of project management’.

The question remains on how to engender cooperation and share the project execution benefits between the engineering teams and human resource groups. The EPCM Company has to ensure there is some residual benefit from the completed and handed over project and that the project team gains from the project experience. In addition, there has to be development of a common goal and reinforcing of the intercompany relationships.

Linking knowledge management and project leadership Kelly, Edkins, Smyth and Konstantinou (2013) discussed the successful management of project challenges. Kelly et al (2013) found that the management of knowledge is important for resolving the project challenges frequently faced by major contractors. Knowledge management is of key importance to ensure tried and tested solutions to project challenges are adapted and implemented as required. However studies performed in the UK in 2013 suggested that the process of knowledge sharing is seldom featured as a project practice. Kelly et al (2013) noted that projects are frequently set up with inadequate budgets for knowledge management. They also found that there is a lack of personnel continuity
through the project life cycle and also poor handovers, additionally, the task orientation on projects cut across benefits derived from information sharing. There is a lack of knowledge sharing between projects in execution and, at the completion of stages of the project. At the completion of the project personnel are dispersed without capturing experiences. Interestingly Kelly et al (2013) identified support for the more open plan structure for the office environment as in this environment personnel are forced to share knowledge. They also noted that organisations generally are not committed to knowledge dissemination.

Kelly et al (2013: 666), stated, 'attitudes towards the use and value of knowledge varied considerably from one project manager to the next and that the overall approach to knowledge sharing could better be described as dynamic and emergent, rather than uniform, systematic or organised'. From their study, project managers did not see themselves responsible for the management of knowledge beyond the boundaries of their project. There is therefore a need for a commitment from the project manager for knowledge collection and knowledge sharing.

Mvudi, Pretorius and Pretorius (2012) review knowledge based engineering and knowledge processing for reducing the product development time. The approach proposed by Mvudi et al (2012) is a method that aims at establishing a process for converting engineering design knowledge into programming code. This is to develop a process that can help engineers capture engineering knowledge and to present it in a form that makes it convertible in ‘object-oriented’ language. The method employs the use of a hierarchical representation of the model, the design knowledge and a knowledge conversion table. According to Mvudi et al (2012) the process addresses the need to capture information from engineering personnel and knowledge flow to programmers. Certain aspects of this is relevant for the design of new equipment for the large multidiscipline mining project, it would require development however.

The hierarchical approach entails two main steps: the hierarchical representation of the model, the hierarchical representation of the design knowledge. These steps are detailed below. Robinson et al (2005: 431) state that, 'Learning and knowledge sharing are essential drivers of innovation in order to sustain the long-term competitive advantage of organisations. The industry has also been made increasingly aware of knowledge sharing through initiatives such as the Construction Best Practice Programme (CBPP) and Movement for Innovation'. Robinson et al (2005) identify the necessity thus, 'knowledge is the hidden asset of organisations, which has to be nurtured for long-term corporate sustainability and knowledge management is a method of exploiting, or transforming knowledge as an asset for organisational use to facilitate continuous improvement'.

Robinson et al (2005: 432) state, 'Knowledge is vital for business improvement but it is not the knowledge of the organisational members per se which is of critical strategic importance, it is the firm’s productivity in building, integrating and utilising its intellectual capital which is vital'. They identify organisational knowledge as; ‘individual and group knowledge, internal and external
knowledge, and tacit and explicit knowledge’. Robinson et al (2005) define tacit and explicit knowledge, ‘tacit stored in the heads of individuals and is difficult to communicate externally or to share. Explicit knowledge is captured or stored in an organisation’s manuals, procedures, information systems, and is easily communicated or shared with other people’. Tacit and explicit knowledge is a key differentiator for the EPCM Company. The EPCM company has to be in a position to identify the sources of knowledge and the nature of the knowledge, the company must identify the means to capture and disseminate this knowledge.

For Robinson et al (2005: 433), ‘Knowledge management relates to unlocking and leveraging the different types of knowledge so that it becomes available as an organisational asset. Implementing knowledge management enables an organisation to learn from its corporate memory, share knowledge, and identify competencies in order to become a forward thinking and learning organisation’. They argue that ‘knowledge management initiatives can help attract and nurture top talent, as maximising access to knowledge across the organisation can accelerate the learning experience of new employees, build more knowledge and increase organisational capability’. As seen before ‘knowledge management can drive innovation, helps to attract new and retain valuable customers, and in the process increase organisational productivity and profitability’.

As seen it is core to the EPCM Company to be able to learn and, retain and implement this learning to the benefit of the client through reduced cost, reduction in program duration and greater assurance of success. The EPCM Company has to be in a position to gain, as a holistic entity, from the explicit and tacit learning gained from project execution.

For Landaeta (2008) knowledge is one of the competitive advantages in project execution. ‘Consequently, the effective management of organisational knowledge has become a critical organisational capability’. This ‘makes the application of cognitive processes a critical factor for quick response in continuously and unpredictably changing environments’. The temporary nature of the project and the tendency for complexity and uncertainty makes the process of retaining the project learning more challenging for the EPCM Company, complexity and uncertainty will be discussed in a separate section, it is however necessary that the EPCM Company continues to grow the knowledge base to maintain a competitive advantage.

Landaeta (2008: 29) describes the nature of knowledge management ‘Knowledge management in projects includes the policies, tools, and knowledge processes that projects and project-based organisations can use to take advantage of the knowledge that is available within and outside projects’. According to Landaeta (2008: 30) ‘A knowledge system enables the management of knowledge. The inputs of a knowledge system include both the elements that provide direction and define the system, as well as the elements that make possible the operation and control of the knowledge system (e.g., hard and soft support from senior management, the vision and goals of the knowledge system). The operation of the knowledge system involves the execution of both the knowledge processes and of the knowledge support processes formally and informally’.
It was found that there was a positive relationship between the transfer of knowledge and the performance of the project involved in the knowledge transfer. It would appear that the act of knowledge transfer resulted in an increase in performance possible as it facilitated an embedding of the project experience, and a reappraisal of the lessons learnt. The study also noted that the development of a project body of knowledge stimulated the knowledge transfer across the projects. The tacit knowledge gained at an individual level should not be disregarded.

According to Landaeta (2008: 36) the effectiveness of the knowledge gained is dependent on the following aspects:

‘The member of a project team that transferred knowledge across projects:

- Was able and willing to recognise and disseminate knowledge from other projects that could be beneficial to other members of his/ her project team,
- Had a high influence upon the project’s operations (e.g., project manager, project lead),
- Was in charge of a critical activity for the project (i.e., an activity in the critical path or that is a predecessor of an activity in the critical path),
- Was in charge of performing a large portion of the total number of activities in the project,
- Was trying to gain knowledge to resolve issues, problems, crisis, or disasters at the project level (i.e., not at the lower levels of work packages or activities in the work break down structure),
- Was able to transfer knowledge across projects effectively and efficiently’.

Further according to Landaeta (2008) the key to effective knowledge transfer is to select the correct persons:

- Experienced in knowledge transfer,
- Sufficient ability to understand the project,
- Good at forming relationships.

The effectiveness is directly linked to the commitment to the process from the organisation leaders and the senior management. The key knowledge needs to be identified and the persons to effect this need to be identified and time provided. The architecture required for knowledge retention needs to be optimised to ensure the information is readily available.

Loo (1996) discusses project management training for improving individual and team performance. Loo (1996) advocates the project management approach to many aspects of business, perhaps a wide spread understanding of project management principles would improve the holistic efficiency of business?

For the ideal state Lindkvist (2005: 1189) describes an organisation where the group becomes a tightly knit community, particularly where they have been working together for a long time.
Lindkvist (2005: 1189) tables the term ‘community of practise’. Lindkvist’s (2005: 1189) “community-of-practice” has become a highly influential way of conceptualising how sub-units or groups within firms or organisations operate. ‘Community-of-practice refers to ‘tightly knit’ groups that have been practising together long enough to develop into a cohesive community with relationships of mutuality and shared understandings.’ Lindkvist (2005: 1207) states, ‘In knowledge communities vital knowledge is decentred, residing in the activities, the narratives, or the culture of the community. In such a context there is little reliance upon idiosyncratic individual knowledge. Establishing such a knowledge community with a decentred, yet holistic knowledge system capable of guiding work in a cultural manner, would seem to benefit from periods of stability and relative isolation’.

In the typical project management type community there is less of the knowledge community type approach to carrying out the business of the company and more reliance on individual knowledge bases and inter-company connections. This would tend to indicate the need for two types of knowledge sharing in the typical EPCM Company.

As stated by Lindkvist (2005: 1207), ‘Rather than resting on communal background knowledge, or individual knowledge base similarity, concerted action is here a matter of the well-connectedness of individual knowledge bases. Great reliance is thus placed on individualised knowledge, but also organisational or social knowledge is important.’

Mathur, Jugdev and Fung (2013: 112) explore the relationship between these project management assets and project performance outcomes, this is another competitive advantage for the EPCM Company. Mathur et al (2013) see project management capabilities as a being a distinct source of competitive advantage. The authors see project management skills as be a sub-set of resources of a company. From Mathur et al (2013: 113) resources are considered strategic ‘if they have the following competitive characteristics, they provide economic value, they are unique, they are difficult to copy, and they have organisational support’. This is fundamental to the business of the EPCM Company as this would be the sole source of the business of the EPCM Company, the rarity value would have to be maintained. Also according to Mathur et al (2013: 113) ‘the project management process has been getting an increasing amount of attention as a means to improve a firm’s competitive position’. ‘The academic literature has, however, focused primarily on operational aspects of project management, and the role of this process as a strategic capability, while it has been recognised, is still understudied’.

Mathur et al (2013: 115) say ‘the lesser-studied intangible project management resources that are more likely to be rare and inimitable, and therefore more likely to be sources of competitive
advantage. Intangible project management resources include tacit knowledge, the application and sharing of tacit knowledge, and processes and relationships for facilitating this sharing. While explicit knowledge is more formal, codified, and transmitted systematically, tacit knowledge is shared informally through social exchanges and some examples in project management include brainstorming, mentoring, learning through shadowing, and storytelling.

Mathur et al (2013: 125) discuss the value of project management resources:

- Assets that capture and disseminate project management knowledge and IT tools which enable application and sharing of this knowledge,
- Assets which are embedded in the routine and relationships of a company, these being assets which are hard for a competitor to copy,
- Project management alignment, project management communication, and project management integration, all of which contribute to embedding project management practices into the fabric of a company’s culture.

Javernick-Will (2013) writes ‘multinational, project-based organisations are faced with competing challenges of adapting to a local marketplace and integrating various offices globally’. The author found that ‘that firms with a low level of local embeddedness have more formal knowledge management platforms to share local knowledge, whereas firms with a high level of embeddedness, which require the most local knowledge, lack formal knowledge management strategies to share their knowledge across projects’.

Javernick-Will (2013: 16) states that ‘each project location has different institutions, regulations, norms, and cultural-cognitive beliefs, that the organisation must understand and to which it must adapt in order to gain local legitimacy for the project. At the same time, one of the key competitive advantages of large, multinational organisations is the organisational knowledge they have accumulated in multiple markets over time. If this knowledge is recognised, integrated, and transferred, it can be a resource as important as capital to the firm and can positively influence project capabilities and performance’.

The challenge for the multinational project based organisation according to the author is to adapt knowledge to the local market and to convey knowledge across the firm. Also previous studies on knowledge management have treated the company as a homogenous entity; the study conducted by this author adds the facet of local embeddedness in the region of the project.

Javernick-Will (2013: 22) states that the ‘firms which are most embedded within a project location primarily rely upon social methods to transfer knowledge, which may or may not reach across projects and geographies’. The author continues stating that ‘as a result, they have less reliance upon the organisation to achieve these results, and, instead have increased reliance on the local population’. In reflection the author writes ‘On the other hand, engineering consultants continue to work on multiple projects in diverse locations at the same time. They frequently remain at a
company office and continue to interact primarily with colleagues within the organisation. They also have fewer project and local relationships than general contractors or developers. In addition, due to the lack of requirement to be staffed on site and the desire to condense project durations, multinational engineering firms distribute work geographically’.

According to Javernick-Will (2013: 24) the implications are ‘engineering managers must carefully examine the knowledge management strategy employed and the level of embeddedness for their organisation and projects. Specifically, they should examine the types of knowledge that are important to utilise on the project and determine if this knowledge requires a large degree of local knowledge or, instead, generalised knowledge that can be obtained from the organisation’. This according to the author will determine if the project team should adopt a local project implementation strategy or adopt a global implementation strategy. The down side is that the global entity will not benefit from the implementation with an increased knowledge database.

In conclusion the author states that the degree of embeddedness and the regional nature of the knowledge are linked. The degree of local embeddedness is linked to the knowledge management strategies of the company. Engineering companies tend to have more formal knowledge management systems and would therefore tend to be less embedded in the region.

Akhavan and Zahedi (2014) examine the importance of knowledge management and ‘provide guidelines to organisations adopting knowledge management from different perspectives. Concepts were extracted from the findings and a conceptual framework was formed to show how to adopt and manage knowledge management in project organisations in order to benefit from its advantages’. The authors state that knowledge management within an organisation requires a detailed and precise alignment of strategies and operational procedures. Further Akhavan and Zahedi (2014: 20) state that ‘numerous organisations have been profoundly interested in knowledge management systems’. In temporary project organisations, no appropriate mechanism is recognised in order to gain, store and propagate knowledge to enhance the level of organisational learning. At the same time, more companies are now managing their businesses by adopting project strategies.

Akhavan and Zahedi (2014: 28) identify the following elements in knowledge management:

| Knowledge Structure: establishment of knowledge structure is of high importance, demanding significant level of accuracy, appropriateness, and consistency in order to be able to respond to the business requirements and objectives. |
| Knowledge Sharing: it is important to provide the necessary facilities and sufficient time gaps in order to make knowledge sharing as a routine procedure inside the organisation. Senior managers need to provide a proper atmosphere inside the organisation in order to facilitate knowledge sharing among the staff. |
| Knowledge Strategy: One of the most important branches of the corporate strategy is knowledge strategy. A clear, well-aligned and well-defined strategy can be employed more quickly and effectively. |
Education Schemes: To direct the knowledge towards the organisational objectives, employees should be trained in recording their information and analysing and providing a proper report to transfer a useful format of knowledge to others.

IT: Should be integrated into the knowledge structure and employees as well as managers should be aware of its impacts, and also have to know how it works. IT influences the success of knowledge management in temporary organisations.

Storing Knowledge: The knowledge management information should be recorded, categorised and stored for future access, large databases and organised methods of storing are needed. If an organisation does not provide easy-to-use system for drawing the knowledge out of, they might not be interested to share their information. Moreover, if the system could not be accessed conveniently, storing could not benefit the organisation.

For Akhavan and Zahedi (2014: 34) organisations need to establish suitable knowledge structures and build their knowledge strategies based on that. ‘Strategies should be aligned in such a way so as to enable and inspire knowledge sharing among employees’. ‘IT can help the organisations to better lead their programs and provide more advanced tools for staff to gather their data and establish a more useful knowledge system throughout the organisation’.

Reflecting on project artefacts, for Massingham and Massingham (2014) knowledge management has become an integral aspect of the residual artefacts after the execution of a project. Their paper examines the way that knowledge management can demonstrate practical value for organisations. Massingham and Massingham (2014) cite authors stating that US companies loose USD31.5billion every year through the failure to share knowledge. For knowledge management to have value for a business then there has to be an actual return on investment, knowledge management has to be seen to add balance sheet value to the company. According to the authors some management critics dismiss knowledge management as a new management fad based on the premise that knowledge cannot be separated from the knower. Obviously knowledge is retained by the staff but, with a structured mentoring program and with deliberate and structured knowledge gathering this can be addressed.

The financial aspects of knowledge management examine the following aspects:

- Return on investment,
- Cost benefit analysis,
- Value appropriation.

The non-financial aspects of knowledge management examine the following aspects:

- Corporate governance,
- Benchmarking,
- Performance drivers,
• Problem solving.

According to Massingham and Massingham (2014) in terms of the problem solving aspects the key features of knowledge management are:

• Activity, where there is an increase in productivity and problem solving and thus an improvement in capacity utilisation,

• Efficiency, where staff are enabled to perform their tasks quickly,

• Effectiveness, where the work outputs are of improved quality.

Massingham and Massingham (2014) identified seven challenges to knowledge management; new staff, younger staff, capability gap, slow task completion, work outputs not used, resource cuts, and low productivity.

Each of these aspects can have a profound effect on the company knowledge management. For Massingham and Massingham (2014) the practical outcomes for knowledge management can be measured by:

| Learning curve: impacted by high employee turnover. |
| Experience curve: impacted by losing experienced staff. |
| Strategic alignment: poor strategic alignment is caused by a gap between the capability of the staff member and the organisation’s job requirements. |
| Connectivity: poor connectivity is caused by poor social capital. |
| Risk management: poor risk management is caused by poor corporate governance. |
| Value management: unsatisfactory value management is caused by poor communication with stakeholders. |
| Psychological contract: Unsatisfactory psychological contract is caused by low morale. This means that the job is not meeting the expectations of its staff in terms of their emotional relationship with their organisation. |

They argue ‘that investment decisions regarding knowledge management may benefit from focusing on significant and on-going organisational problems’.

Expanding on the paper of Massingham and Massingham (2014) comes Shokri-Ghasabeh and Chileshe (2014) advocating the value of knowledge management in the company and the particular value of capturing lessons learnt in the tendering environment. They also found that the ‘top-3 barriers to effective capturing of lessons learned were; lack of employee time, lack of resources, and lack of clear guidelines, whereas, lack of management support was the least ranked barrier’. Further for Shokri-Ghasabeh and Chileshe (2014) there is a need for the company to establish clear knowledge management frameworks for the capturing of lessons learnt. In managing the post project review the authors suggest calling a meeting with the right people, ask the right questions, set targets and keep minutes. In a long duration project the meetings should be held more frequently. The meeting needs to be stored by the company and disseminated.

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In addition to the above the authors cite the following as being the framework for a management process for knowledge management:

- Timing for project reviews,
- Project review team,
- Systems approach to a project review,
- Use of TQM tools in project reviews,
- Recording experiences in project review,
- Project review depositories for lessons,
- Specific lessons learned from project reviews,
- Sharing lessons learned from project reviews,
- Implementation plan for lessons learned in a project review.

In the discussion the authors cite the following familiar reasons for not capturing lessons learnt:

- Lack of employee time,
- Lack of management support,
- Lack of incentive,
- Lack of human resources,
- Lack of clear guidelines,
- Lack of support from others in organisation,
- Our process does not capture useful lessons,
- Data repository too hard to search,
- Lessons are not transferable,
- Wrong people are involved,
- We have done enough.

According to the authors the problems are exacerbated by the allocation of personnel to other projects, there should be an initiative for the EPCM company to free up time for the completion of the lessons learnt process.

Wong and Shah (2014) reflect on the knowledge collaboration within an EPCM Company. This is one of the few papers reflecting on EPCM Company practices.

The Professional Publications & Presentations Program (P4) program at Fluor Corporation. The authors state, 'While globalisation has created many modern trends, companies have to adapt those trends promptly in order to survive in today's competitive market. Upon realising the major value of intellectual resources, many companies have begun to manage rationally and improve
them. In other words, companies must utilise internal and external knowledge. However, the practical application of this concept among EPCM companies remains relatively genera’. The authors focus specifically on the extent of external collaboration with regard to the capturing of lessons learnt on to the Fluor P4 database. According to Wong and Shah (2014) Fluor believes that promoting knowledge collaboration with external parties is key to a successful knowledge management system. While many would agree, how can a company encourage an employee to report his/ her explicit knowledge, so that the knowledge can be captured and shared?

Wong and Shah (2014: 3522) identified the following practical impediments to P4 in interviews:

- Insufficient knowledge of the benefits of P4,
- Lack of incentives to participate in knowledge sharing via external publications,
- Insufficient compensation for time and travel expenses when the presentations are held significantly far away from the employee’s work location.

Wong and Shah (2014: 3522) identified the following aspects as being relevant to improve the P4 implementation:

- Social motivations:
  - Authors are given certificates and plaques,
  - Authors have more chances to work or interact with subject matter experts or company fellows,
  - Authors receive appreciation letters from the operations managers,
  - The Chief Executive Officer actively promotes and advocates P4 via corporate newsletters.

- Benefits of P4 to Fluor Employees:
  - P4 provides a pathway to rapidly leverage the experience of the experts throughout the company. This philosophy allows one employee to represent the employees’ knowledge of Fluor as the whole,
  - Co-authoring in P4 with authors from different departments or office locations shifts employees’ focus back to the entire organisation and not just one department.

- Effects and Benefits of P4 for Fluor:
  - Increased Effectiveness of Personnel; the speed at which new employees come to understand company policies, procedures and work-processes,
  - Increased Accuracy and Competencies of Proposals; the capture of historical information, as well as current industry data, allows Fluor’s Marketing and Sales team to make confident and timely bids on future proposals,
- Improved Worksharing; globalisation and worksharing require experts' knowledge to be well-documented and accessed globally,
- Increased Client Confidence; clients are assured that the Fluor has the right expertise to execute their projects.

In conclusion Wong and Shah (2014) state that the effective implementation of P4 would sustain the competitive advantage of Fluor in the market place.

Regarding the impact of project disruptions on the human resource, Howick and Eden (2007: 2775) state, 'the majority of large, complex projects suffer (and suffer from) disruptions. These can have unexpected and significant impacts on a project, resulting in excessive time and cost overruns'. Disrupted projects require careful management to minimise the impact of disruptions. ‘An understanding of the impact of a particular disruption on learning is required to enable effective management of that disruption’. The disruption can result in the dispersal of the project team within the parent organisation or the loss of the project team members to other organisations. In either event the effect on the project is the loss of the acquired individual and group learning, and the detailed knowledge of the project.

Howick and Eden (2007) are specifically referring to the aerospace environment but there is evidently congruity to the role of the EPCM Company in the large engineering infrastructure or mining project. For the client’s benefit not all of the information can be captured in the form or drawings, reports, ‘notes for the record’, scopes of work and specifications.

The impact of project delays on the execution of an EPCM project would bear the execution of a similar study. There is a duty to be able to elucidate the effects and risks of delays on the project execution and the need to put into place tools and techniques to mitigate this effect for both the EPCM Company and the client.

Howick and Eden (2007: 2778) were able to plot graphs of the process improvement against time. This representation would be more challenging in the EPCM environment as the development of the heuristics, the understanding of the client requirements and the development of a beneficial stakeholder management process would be difficult to quantify without the numeration of empirical perceptions.

None the less research in this area would be beneficial for the EPCM Company in ensuring the loss to the client is minimised, and to the client to ensure to the greatest extent there is project continuity and that the EPCM Company is encouraged to develop a supporting team within the EPCM Company.

In this section the importance of the engagement of the human resource department or personnel into the project delivery process was identified. The human resource management is linked to knowledge management within the EPCM company and to manage one aspect is to manage both
aspects. The improvement in project execution performance means that the EPCM company has to manage and measure the development of the human resource.

2.6 Project teams

The aspects of human resources, knowledge management and project teams have a significant crossover within the EPCM Company. Currently there is marked trend towards virtual teams and digital socialising particularly as skilled resources become more scarce with increasing demand. With this trend comes the need to socialise the project team in the virtual project team environment. To a great extent it is the responsibility of the project leadership to establish and develop the temporary project team and to ensure the project team works effectively together.

Coates, Duffey, Hills and Whitfield (2006) discuss techniques and challenges of building engineering project teams. To Coates et al (2006: 1255) managing engineering projects is a complex activity involving skilled engineers with varying capabilities. Projects can experience a marked shortfall in the identification of team members and the allocation of resources to the demands of the resource requirements. The company allocating those resources would not have a surfeit of resources (depth) and a wide range (width) of resources, in a thriving business environment most personnel would be allocated to other projects on a full time or part time basis. Coates et al (2006) developed a resourcing model. The Coates et al (2006: 1255) model identifies the engineer’s skills and the level of capability. This is manipulated by a simple algorithm to allocate the resources to the project. Most project managers will anticipate a resource shortfall but the system will assure the optimal allocation of resources.

Project delivery companies are required to manipulate and match resources to achieve the project objectives to the advantage of the clients. Though this would not create a team in the sense of creating a cohesive project group the economical allocation of scarce resources would have taken precedent.

Scarce resources, ‘lower cost’ centres of engineering skills, the increasingly widespread availability of fast internet communication and video conferencing communication have brought the increasing use of virtual teams and the necessity for ‘digital socialising’.

For El-Tayeh and Gil (2007) socialisation means to convert individual knowledge into group tacit knowledge and, as identified, knowledge management is recognised as an important source of learning and innovation. Socialisation according to El-Tayeh and Gil includes conversations, apprenticeships, and storytelling and this assists in building ‘communities of practice’ or common ground, as we have seen. In addition El-Tayeh and Gil (2007) discuss the cross firm socialisation opportunities offered by the Internet; they also describe the requirements for socialisation as offered by informal communication and by impromptu conversations.
El-Tayeh and Gil (2007) elaborate on the principles of digital socialising of teams in the following table 2.3:

**Table 2.3 – Digital socialising: derived from El-Tayeh and Gil (2007)**

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Digital implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility of social information</td>
<td>Individuals need to draw upon their social experience and expertise to structure their interactions; excessive visibility can be detrimental.</td>
<td>Random picture galleries, graphical-based chat.</td>
</tr>
<tr>
<td>Reputation of individuals</td>
<td>Individuals need to know about other individuals’ identity and their past action to overcome the reluctance of individuals to cooperate and interact.</td>
<td>Reputation mechanisms, predictive utility indicators.</td>
</tr>
<tr>
<td>Social awareness</td>
<td>Individuals need to understand how others’ activities provide a context to one’s own activity, including cues about availability and situation (is individual busy, away, or at lunch?), and knowledge (does individual have specific knowledge or knows who has it?).</td>
<td>Social proxies using sound and/or graphics to portray salient aspects of digital socialisation.</td>
</tr>
<tr>
<td>Synchronicity</td>
<td>It facilitates the creation of “common grounding” by allowing to clarify in real-time possible misunderstandings and misinterpretation of ideas.</td>
<td>Chat, video–audio links.</td>
</tr>
<tr>
<td>Persistence</td>
<td>It provides history and context that exist beyond the immediate here and now to develop long-term interdependent relationships.</td>
<td>E-mail, bulletin boards.</td>
</tr>
</tbody>
</table>

El-Tayeh and Gil (2007) conducted a case study within an engineering consultancy to review the social acceptability of various media in the exchange of knowledge. They were explicitly looking at people’s perceptions on the use of various media in the dissemination of knowledge within the company.

Socialisation through face to face meetings: El-Tayeh and Gil (2007) reported on the usefulness of meetings in speeding up problem solving, providing an environment for drawing reviews and presentations and for more sociable interaction with colleagues from other firms. To an extent the meetings create a common grounding but they are, according to the study difficult to coordinate and assure attendance, and are time-consuming. The meetings become ineffective if the key personnel cannot attend and minutes are difficult to maintain especially if the details of the meeting cannot be captured.

Socialisation through telephone and eMails: El-Tayeh and Gil (2007) reflected on the respondents’ use of the telephone for clarifying technical and managerial issues during the project execution. Regarding the use of electronic mail - there is a wide spread use of eMail communication as the respondents are able to attach relevant images and reports. El-Tayeh and Gil (2007) reflected on the slow and sometimes ambiguous nature of eMail discussions which can become misunderstood and time consuming.
El-Tayeh and Gil (2007) reflected on the poor use of the Extranet set up by the company, most found it to be cumbersome and too open to be comfortable place to exchange correspondence and too open to exchange documents.

Expanding on the theory and practice of the virtual, web based project team Nitithamyong and Skibniewski (2010) discussed the web based project management systems.

There is more industry focus being placed on the substitution of conventional management systems with web based systems. However, Nitithamyong and Skibniewski (2010) discuss the delayed effective roll out of this initiative as being due in no small part to the lack of understanding of how it can be effectively implemented. Certainly as project teams and resources become wider spread there will be a greater and greater need for the implementation and acceptance of web based project management systems.

Hamersley and Land (2015) explore further team building in the virtual project environment and that ‘The steady increase in project failure rates is leaving businesses searching for better integration techniques to virtualise their project environments’. According to Hamersley and Land (2015) there is an opportunity to maximise the use of resources alleviating regional resource constraints.

According to Hamersley and Land (2015) there are significant benefits to the adoption of a dynamic virtual work environment including the blending of cultures, values and work ethics. From Hamersley and Land (2015) the high failure rate in projects is directly related to the lack of project team governance and knowledge of project management. Thus, according to Hamersley and Land (2015) there is a need for the virtual project and governance of the virtual project team. Hamersley and Land (2015: 5) identified ten emergent themes:

| Management: is the primary component of successful virtual project teams. |
| Environments: are diverse for virtual project teams. |
| Collaboration: is mandatory for the success of virtual teams. |
| Understanding: the elements of virtual project management provides clarity to the environment. |
| Structure: of virtual project teams is essential. |
| Efficiency: is the key to prolonged virtual project team success. |
| Skills: are requirements to integrate team members into virtual project teams. |
| Diversity: is inherent in geographically dispersed virtual project teams. |
| Governance: is a major part of business and project management structure. |
| Technology: is a requirement for virtual team collaboration. |
For Hamersley and Land (2015) the virtual project team is the team of the future as resources become more scarce and are required in different locations, at the same time the high standards required of the execution team cannot be compromised.

Wong and Zhang (2013) discuss the implementation of web-based construction project management systems by Hong Kong property developers. They examine the challenges of web based construction management systems and then review the techniques to mitigate and solve these challenges. The authors analyse the project failure factors and then review the proprietary project management software systems as techniques for mitigating the failure mechanisms. Wong and Zhang (2013: 26) observed the cooperation and coordination difficulties among participants caused by project distance and remote management control as being a cause of project failure. According to Wong and Zhang (2013) there was a rush to implement web based project management systems as the predominant problem is one of management as opposed to the technical project challenges.

Wong and Zhang (2013: 28) state that ‘Project success relies heavily on the timely transfer of information between owners, project managers, general contractors, trade contractors, city authorities, inspectors, designers, and lawyers’. Researchers, according to the authors have identified problems associated with long distance construction project management as being inadequate communication and poor information processing which induces the proliferation of adversarial relationships between stakeholders in different project phases and subsequently overall project performance is affected.

For Wong and Zhang (2013) technology is no longer a constraint in the implementation of web based management systems. Project managers can monitor progress through web based camera systems on remote sites. In the more recent developments the web based project management systems have evolved to include procurement and financial management systems. According to Wong and Zhang (2013: 36) ‘WPMS mainly focuses on the design phase, contractor selection phase, project mobilisation phase, and project operation phase, rather than pre-project phase or project closeout and termination phase’. According to Wong and Zhang (2013) a leading Hong Kong property developer has established an intelligent project management system that will act as a depository for all project information and communication, such information would include:

- All project data, contained in reports, memos, drawings or photographs,
- Letters, project memos, RFI, confirmation of verbal instruction, safety instruction and quality instruction, submission for approval, working instruction and drawing instruction, meeting minutes and cost reports,
- Procurement documents,
- Design data and drawings.
Wong and Zhang (2013: 42) discuss the benefits thus:

‘Before implementation distant geographical locations and the consequent remoteness of management controls caused difficulties both in coordination within the developer’s own organisation and cooperation between participants’. ‘Communication and information handling in real estate construction projects can be chaotic, leading to lapses in communication, poor understanding, and ultimately, to annoyance, conflict, and cost and schedule overruns’.

After implementation the participants can share project information in a centralised system. Communication can be in real time. ‘Each stakeholder employee can access only what he or she needs to know about the project, e.g. schedule, material cost, labour cost, equipment cost, bid, etc.’.

Returning to the project team aspect Hoegl and Weinkauf (2005: 1287) reviewed the tasking of teams and the effect on team performance. Though aimed specifically at product development projects in the automotive industry there are aspects of relevance to the large multidiscipline mining project. Further Hoegl and Weinkauf (2005: 1287) state, ‘we examine project-level and team-level managerial functions aimed at managing inter-team task interdependencies and investigate their effect on the performance of teams in a multi-team product development project’. The results of their study show that team interface management is particularly important during the concept phase of the project. Project structuring and support is most important in the development phase of the project. Hoegl and Weinkauf (2005: 1301) emphasise the importance of team interface management in the early phases of the project.

Hoegl and Weinkauf (2005: 1301) discuss the building of team relationships, ‘it is in the concept phase where teams must identify related teams and develop good working relationships quickly to aid their module concept planning and their ability to ultimately achieve product quality targets while adhering to schedule objectives’. ‘Interface management should take place early in the project and is critical for negotiating technical arrangements between teams based on given technical interdependencies’.

The relevance to the large multidiscipline mining project is apparent particularly where the teams are relying on the client and other external technical representatives for information and clarifications.

Contrary to the Hoegl and Weinkauf (2005: 1302) prediction, project structuring and support in the concept phase showed generally negative effects on team performance, but showing the expected positive influences in the development phase. In the early concept phase of the project the authors found that there were benefits in allowing the teams to be more self-managing. Hoegl and Weinkauf (2005: 1302) state, ‘It may be that in the early phase, the teams better establish and arrange their interfaces among themselves, and project structuring and support may be counterproductive to this endeavour’. Thus it would appear from Hoegl and Weinkauf (2005) to be
important that the teams are allowed to identify their own interdependencies in the early phase of the project, and that it may be counterproductive for the project manager to impose team structures early in the project life cycle.

There would appear to be a different set of team requirements when moving into the implementation phase of the project. There would be a new set of role players coming into the project, particularly those responsible for the implementation and thus looking for the technical details of the output.

Hoegl and Weinkauf (2005: 1302) continue by stating, ‘It is in the development phase where the teams must focus on the implementation of their initial designs, where their attention turns to technical details and economic implications’. ‘As changes inevitably occur due to unforeseen problems, the teams may need to adjust their designs under increasing cost and time pressures and revise prior commitments to other teams’. ‘From this perspective, the sharply differing effects of project structuring and support (i.e. negative in the concept phase, positive in the development phase) may reflect the different managerial requirements in the concept versus the development phase’.

Thus the work of Hoegl and Weinkauf (2005) identifies the differing requirements for project management in the first two phases of the project. This would appear to be relevant to the large engineering project but made more complex as the project could be traversing through two phases at the same time.

Hoegl and Weinkauf (2005: 1303) state, ‘Taken together, the findings from this research highlight the importance of team interface management in the concept phase and project structuring and support in the development phase’. ‘It is the teams themselves that must directly identify interdependent teams and develop good working relationships in the concept phase, where direct coordination and cooperation are particularly important as the basic design of all modules and the overall product are being shaped. In the development phase, however, when the teams are busy with prototype development and testing as well as coordination with suppliers, project managers’ structuring and support serves an important role in ensuring later team success’. Hoegl and Weinkauf (2005) have identified that as the project gets closer to the point where it has to deliver so the costs start to escalate. The costs and delays associated with changes will start to impact on the project viability. So therefore the need for tighter project controls becomes more critical as the project nears the scheduled completion.

Hoegl and Weinkauf (2005) reflect on the importance of this study in so far as the need for the Project Manager to ensure the team members are skilled in the direction of the interfaces in the early stage of the project. They reflect on the reluctance of some of the engineers to take care of the boundaries in the work place. The conceptual phase of the project is often the time in the project where autonomy and creativity are required, even where there are strict statutory and client
guide lines. This is where according to Hoegl and Weinkauf (2005) management is acting as a facilitator rather than a supervisor.

Açikgöz, Günsel, Bayyurt and Kuzey (2013) discuss the effect of team climate on team cognition and the relationship between team cognition and the quality of the team output in the software development environment. The authors also explore the project complexity as a factor affecting the quality of the output in a positive way. According to Açikgöz et al (2013) ‘team cognition refers to the desire to enlarge teams’ knowledge structures. Enlarged knowledge structures enable project teams to form accurate explanations and expectations for a specific task in order to coordinate their actions and adapt their behaviours to the demands of a turbulent environment. It also allows project teams to be more effective in solving problems, to make better decisions, and to face fewer crises during a project.

From Açikgöz et al (2013) the project team environment has to be such as to support the development of a cognitive and intuitive team. When team members are willing to benefit from new ideas, make a joint effort to reach goals, and utilise norms and procedures positively, the team becomes better at acquiring, processing, and disseminating information in a rational manner. ‘When team cognition is supported with a fitting climate, a team's knowledge structures are increased and learning is gained through the team's information-processing mechanisms’. Açikgöz et al (2013) define the following steps in establishing the conducive team environment:

| Generate a shared vision among team members in order to establish clearly defined, allocable, and attainable objectives. |
| Direct the collective efforts of team members to reach goals of quality. |
| Establish a psychologically safe environment where team members are encouraged to use their experiences and to collaborate freely with each other without fear of reprisal. |
| Provide support for innovation to encourage team members to introduce novel ways of doing things. |
| Provide norms and procedures to enable team members to specialise in their tasks and improve their capabilities in order to produce high-quality products. |

Chan (2014) examines the topical aspect of individual performance from multiple project complexities. The individual in the virtual EPCM project management environment is becoming more and more involved in more than one project. This phenomenon Chan (2014) terms multiple team membership. Chan (2014: 76) states ‘when a person is working in multiple project teams simultaneously, he/ she may encounter more diverse sources of ideas across all teams and thus enhances his/ her innovative performance’. As this complexity increases so the performance will start to tail off. According to Chan (2013) the years after the 1990’s has shown a marked increase in companies applying project management techniques and structures to their business. As the demands have increased so has the propensity to apply individuals to more than one project. According to Chan (2013) there is a need for the individual to socialise in the project teams, too
many team memberships can increase a person’s stress level due to working excessive hours in meeting the demands of various leaders or clients across projects, a decrease in performance may occur. Chan (2013) asks the question ‘to what extent does MTM (multiple team membership) impact on individual and team performance?’

Chan (2013: 84) conclude thus, ‘Working in teams is regarded to be more effective than working individually especially when individuals are working on complex tasks’. ‘Within a multi-project-environment, scheduling human resources in simultaneous projects is inevitable’. ‘This implies that an individual may simultaneously work in multiple project teams’. Further ‘when an individual is simultaneously involved in multiple project teams, at first he/she will have higher individual innovative performance; however, there exists an optimal number of teams, beyond this number, the individual innovative performance will start to decrease’.

Another topical issue is staff retention in an economic downturn. Bettinger and Brown (2009: 4-1) discuss the retention problem currently being faced by many companies as the current economic downward trend continues. The large multidiscipline mining projects are equally vulnerable to poor economic trends. Bettinger and Brown (2009: 4-4) state revealingly, ‘For an organisation to build sustainable success, they must focus on developing people instead of only developing technical competencies’. ‘In the long run, it is not only technology and processes that give an organisation a competitive advantage; it is also their people’. ‘The differences between the two focuses are night and day: one emphasises equipping people to lead and add value to the organisation through innovation and critical thinking’. ‘The other equips employees with the hard, technical skills needed to get the job done’. ‘Technical training is a valuable part of an organisation’s success, but it is employee development that will retain a team’s top talent’.

According to Bettinger and Brown (2009), in the recession of 2008 many US companies applied themselves to developing their talented employees rather than downsizing. Further Bettinger and Brown (2009) state that companies should focus on the development of employees rather than just on arming the employee with the necessary technical skills, the development of the employee generates the retention strategy that will ultimately build the company.

Bettinger and Brown (2009: 4-7) also state that, ‘Employee engagement is vital to the success of organisations, especially in times of recession where news of reductions in force is abundant’. ‘Employees do not simply want to remain employed; they want to do their best work, but are unable to do so when they are fearful and uncertain of their futures’. ‘If employees are not engaged in their projects or organisations, they will begin to “test the waters” and begin speaking with companies who can engage them’. ‘Organisations are in danger of loss, unless they can effectively engage their employees’.

For a differing view on the aging team metrics, Marin and Geiger (2013) examine ‘the issues relating to the aging labour market, the aging workforce, retirement, the different perceptions about
the older worker and the global approach to the issue’. Then the authors review ‘the motivation behind the idea of getting the most out of the sector of the population who is aging and considering retirement’. According to Marin and Geiger this has an effect on the medical and pension resources and the remaining demand for resources. According to Marin and Geiger (2013) employers ‘have to realise that a great link exists between the aging worker, personnel policies, training programs and the job demands. The workplace must include the older crowd in their training, retraining and innovation programs’. Their studies also show that a ‘highly-educated resource pool has positive attitudes towards to both junior and senior counterparts’. Marin and Geiger (2013: 4123) concede that ‘people are an enterprise’s greatest asset. However, people are changing employers on a regular basis for several reasons, including for higher salaries and for greater opportunities. It has been argued that people are more prone to change employers than ever before. In addition to employee turnover, enterprises are also faced with an aging workforce’. According to Marin and Geiger (2013) employers are asking two questions:

<table>
<thead>
<tr>
<th>How do we retain our most knowledgeable and experienced employees?</th>
<th>How do we monopolise on the sector of the employee group that is nearing retirement?</th>
</tr>
</thead>
</table>

In conclusion Marin and Geiger (2013) state that the ‘background information available for an aging workforce and acknowledges the proactive approach of some of the developed countries’. ‘The contribution of this research effort proposes a methodology that filters and prioritises employee characteristics, and then uses those results as the basic input attributes for agents that act as individual employees, hiring managers and projects and programs’. The intent of the paper is to take into account the aging sector of the population that is actively working and may or may not be thinking about retiring, this resource needs to be brought into the training and mentoring policies of the EPCM company.

The project team is established for the sole purpose of delivering the project to the satisfaction of the client. The EPCM company has to select the team members for either full time or temporary assignment to the project and ensure the team members are socialised to the team and project requirements. Within the long duration project execution period there will be a necessity to training, motivate and develop staff and to establish a retention policy for the time when the project reaches a conclusion or is closed.

The EPCM company therefore has the dual responsibility of staffing project teams and managing the resources of the EPCM company.

### 2.7 Complexity and uncertainty

One of the pressures that the project team will face equally will be the complexity and uncertainty of the project environment. With the pressure of time, the availability of funding, the need for
greater technical integrity and intricacy, and expanding stakeholder groups has come the greater uncertainty and complexity of the project and the increasing need to address this complexity to assure successful completion. The large multidiscipline mining project is an example of project complexity and uncertainty often being a collection of smaller projects in various stages of completion, with complexity and an uncertainty due to an incomplete, evolving project definition.

Also not to be excluded from the discussion on complexity and uncertainty are the two aspects of deviations and unpredictability. These two additional aspects can be expected to manifest in the execution of a large multidiscipline mining project.

The eighteen papers reviewed here discuss the aspects of project complexity and uncertainty.

Vidal and Marle (2008: 1094) in their paper saw the need for complexity awareness as introducing a significant risk to the project to be addressed to better assure project success. Vidal and Marle (2008) define and model complexity as a means to manage the conditions of complexity and the associated risks. Vidal and Marle (2008) seek to differentiate between the definitions of project complexity and project uncertainty. It is important to differentiate between these two aspects so that they can be uniquely addressed later. Vidal and Marle (2008) state that there are two basic defining forms of complexity, there is the project complexity as defined in the technological and organisational complexity. The other is the perceived complexity of the project as understood by the observer.

Vidal and Marle (2008: 1097) arrive at four key groups of project complexity drivers; system size, interdependence, variety, and context. Naturally, according to Vidal and Marle (2008) the size and variety of the project systems is a significant complexity contributor. This increases the number of interactions within the project. They also highlight the interdependencies within the project system as being likely one of the drivers of project complexity. Vidal and Marle (2008: 1098) state and cite thus, it is suggested ‘that traditional project management tools cannot be sufficient to catch the reality of interdependence’.

Vidal and Marle (2008:1098) also comment on the context complexity of the project, as being practices that apply to one project are not directly transferable to other projects. Consequentially project complexity can be neither analysed nor managed without considering the implications of the environment of the project. Vidal and Marle (2008: 1101) put forward a definition of project complexity:

Project complexity: is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system. Its drivers are factors related to project size, project variety, project interdependence and project context.

According to Vidal and Marle (2008: 1101) ‘there is a high number and great diversity of objects to manage, with a high number and great diversity of parameters that characterise them. The amount and diversity of these interactions are so huge that project objects rapidly become
unmanageable due to the sole use of classical tools and methods of project management. Both the environmental and the internal complexity of the project warrants the need for a new approach to project management. The authors continue by discussing one of the negative consequences of project complexity as being uncertainty.

Vidal and Marle (2008: 1103) discuss some of the more concerning aspects of project complexity driven uncertainty as being a source of indecision and unpredictability. Thus from Vidal and Marle (2008) it can thus be deduced that complexity and the induced uncertainty can be a significant source of risk to the project, thus the project in its self can become a significant source of risk to the project, and one that needs to be managed. Vidal and Marle (2008: 1104) have identified the two main sources of complexity risks in the project environment:

<table>
<thead>
<tr>
<th>Risks which are directly induced by project complexity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks which are indirectly induced by project complexity because of the propagation phenomena within the project complex system.</td>
</tr>
</tbody>
</table>

For Vidal and Marle (2008) it is of great significance to identify the sources and consequences of the project complexity so that the risk that it induces can be identified and managed. Vidal and Marle (2006: 1105) generated the following table 2.4 of a complexity model requirements:

Table 2.4 – Complexity model requirements: derived from Vidal and Marle (2006: 1105),

<table>
<thead>
<tr>
<th>Complexity theoretical requirements</th>
<th>User requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of the project system</td>
<td>Validity and reliability of the model</td>
</tr>
<tr>
<td>Variety of the project system</td>
<td>Intuitiveness and understandability of the model</td>
</tr>
<tr>
<td>Interactions and interdependencies within the system</td>
<td>Suppress unnecessary detail</td>
</tr>
<tr>
<td>Context and environment dependency of the project system</td>
<td>Completion and concision of the model</td>
</tr>
<tr>
<td>Uncertainties and change propagation as consequences of complexity</td>
<td>Computability of the model</td>
</tr>
</tbody>
</table>

Vidal and Marle (2006: 1105) state that the complexity model must make the important aspects of the project system explicit. predominantly all the important interactions within it and all the important context elements. For Vidal and Marle (2006: 1106), a good complexity model should enable its users to focus correctly on aspects of the system and the action of modelling is in essence a way to reduce perceived complexity to enable understanding. The aspect of complexity will recur in other sections of this thesis as we discuss the granularity decisions for work breakdown structures, and project planning levels (a dimension of project complexity).

Vidal and Marle (2006: 1108) conclude with the following statement, 'This complexity-driven approach of project management seems to be a promising approach to assist project management
in both academic and industrial environments’. ‘As a whole, this approach may lead to the elaboration of complexity-based criteria that could help project scenario selection in the case of project management or that could help project selection in the case of multi-project management’.

Continuing on the topic of project complexity Geraldi, Maylor and Williams (2011: 966) discuss the inherent complexities of projects. Geraldi et al (2011: 967) identify an independent variable as being the fundamental complexity of the project, ‘understanding this variable will be of significant benefit to project managers who have to deal with the complexities of projects in practice’. They suggest that complexity is neither fully understood nor correctly managed.

Project complexity is becoming the norm for project management and it has become essential to understand complexity and to manage the risk associated with this complexity. Geraldi et al (2011: 967) state that analysis of complexity will help the project manager project making the business case, making calculated choices, choosing the management processes, and making decisions during project execution.

Following on from Vidal and Marle (2006) Geraldi et al (2011: 976) state: ‘Structural complexity, the most mentioned type of complexity in the literature, is related to a large number of distinct and interdependent elements. This is close to the original concept of complexity as a set of interrelated entities’. ‘The majority of the articles define structural complexity based on three attributes; size (or number), variety and interdependence.’ Geraldi et al (2011: 976) also identified the following aspect: ‘Uncertainty has also emerged as a relevant type of complexity’. ‘Uncertainty relates to both the current and future states of each of the elements that make up the system being managed, but also how they interact, and what the impact of those states and interactions will be.’ As we will see in project risks Geraldi et al (2011: 976) dwelling on this topic state, ‘For managers, this is experienced as an inevitable gap between the amount of information and knowledge ideally required to make decisions, and what is available’. Thus for Geraldi et al (2011: 978) project ‘dynamics refers to changes in projects, such as changes in specifications, management team, suppliers, or the environmental context’.

Geraldi et al (2011: 978) continue by stating, ‘These changes may lead the project to high levels of disorder, rework, or inefficiency when changes are not well communicated or assimilated by the team and others involved’.

The dynamics of the project changes therefore have to be mitigated by adequate communication. Geraldi et al (2011: 978) state that, ‘Dynamic is a prevalent behaviour of complex systems. However, while the complex projects literature expresses a bias towards minimising and controlling dynamics, the literature on complexity theories in general welcomes complexity’.

In the project environment, the project manager will seldom be too far from a client that is requiring the project to be accelerated or in another scenario where the start has been delayed, additional
scope, or the project receives mid-term delays. Thus Gerald et al (2011: 980) discuss ‘pace’ as a facet of project complexity, ‘Pace: is an important type of complexity as urgency and criticality of time goals require different structures and managerial attention’. ‘Authors on this topic emphasise the need for concurrent engineering to meet tighter project timeframes’.

People add their own complexity to the execution and delivery of the project; this is discussed as the socio-political complexity of the project. For Geraldi et al (2011: 980) ‘behavioural complexity characterises the extent to which there is diversity in the aspirations, mental models, and values of decision makers’.

The socio-political aspect of project complexity cannot therefore be ignored and certain environment may have a background level of socio-political sensitivity that would need to be taken into consideration and due compensation applied. Geraldi et al (2011) has thus identified the five typical groupings for complexity within the project environment; structural, uncertainty, dynamics, pace and socio-political. In drawing to a conclusion Gerald et al (2011: 982) state, ‘complexity is something that managers experience, and therefore is appropriate to study through such perceptual means’. The assessment of this type of complexity is subjective and will be influenced by the project manager.

Volatility could be an aspect of project complexity, this was reviewed by Janse van Rensburg and Pretorius (2013). They state that the in the IT business, an ability to anticipate and respond to volatility induced changes will define the level of robustness and resiliency of the business and will assist in generating profits. This level of volatility may also be present in the execution of a large multidiscipline mining project. Transposing their study into the large multidiscipline mining project environment, the EPCM Company should incorporate project volatility into the business strategy, and have systems in place for detecting, processing and working with this volatility. The EPCM Company should have the skills, resources and abilities to change execution methods. This would have to be appreciated and accommodated by the Client.

Reflecting on the intricacies of communication in complex projects Vaagaasar (2011: 294) reflects on ‘how stakeholder relationships develop and how projects can develop the knowledge, skills, and aptitudes required to handle a multitude of stakeholder relationships’. Vaagaasar (2011) suggests that the need for the project to develop the complex skills required to manage the stakeholder relationships. Certainly there will be a measure of trial and error in the initial stakeholder communication process, experience should however improve the development of the project communication skills. To be effective the project based firm has to be an effective learning organisation.

Vaagaasar (2011: 295) comments on the challenges that are facing many of the projects today in so far as technological innovation and uncertainty, and unwavering delivery dates. ‘This is particularly relevant in the projects that are complex in terms of technological innovation and
number of interfaces among the involved actors’. ‘These highly complex projects also have a high
d level of uncertainty of related to technology, delivery date, and stakeholder landscape’. Vaagaasar
(2011: 295) also points out that the uniqueness of the project enterprise is also extended to the
stakeholder management aspect, ‘both high complexity and uniqueness in technology are factors
that complicate the use of knowledge developed elsewhere. Since the stakeholder environment
for each project might be relatively unique, the reuse of knowledge related to stakeholder
management could be especially difficult. This means that the people in the projects have to
develop these competencies during project execution’. This means that the project team must
have the competency and freedom to develop a functional and effective communication strategy
from own intuition. Vaagaasar (2011) also reflected on the levels of uncertainty during the initial
stages of the project execution and the perceived sensitivity to errors and mistakes of the
execution team. Then Vaagaasar (2011: 298) discussed the need for the project execution team
to be assertive in their approaches to the project owners. The project team has to actively engage
with the owners and become part of the design evolution process. This approach explores the
involvement of the client or project owner in the project processes and the involvement of the
project execution team in the client’s internal processes.

Vaagaasar (2011) discussed the need for the project team to test their own levels of competency
in the execution of technically complex projects. It was necessary at times to seek external
resources and to embed this knowledge in the project team. The evolution of a project with time
will require the involvement of other elements of the client project and operational team and these
elements will be incorporated with time in the user group. The effective project team does not take
the existence of the project for granted; also the stakeholder team is required to keep the project
going.

Vaagaasar (2011) discusses the relationship competencies; this is the process of differentiation
of the stakeholders. The stakeholder can include the various subcontracted activities and the
personalities in the subcontracted resources. Vaagaasar (2011) also reflects on the need to be
able to differentiate between the needs of the various stakeholders and to be able to elicit the
desired response from these persons.

Finally Vaagaasar (2011) concludes by stating that the relationships evolve in the context of a
technology project, the project has to become an embedded project and that communication
competencies are as essential as technical competencies. Relational competencies have to be
developed to suit the normal daily processes of a project in execution and to address the specific
situations at various levels within the stakeholder framework.

The study conducted by Vaagaasar (2011) could be evolved and related to large multidiscipline
engineering and mining projects.
Expanding on the communication theme Cooke (2013) discusses the impact of the pace of technological innovation in construction operation. He argues that the pace of technological innovation has resulted in the increased number of inputs required for a multidiscipline construction project; it would be fair to extrapolate this to the multidiscipline mining project. Cooke (2013) argues that the judicious application information management techniques can allow for data sharing alleviating some of the complexity issues.

Cooke (2013) describes the formidable challenges that technical innovation can present to the project management team. From Cooke (2013: 6) ‘industrial processes have metamorphosed into a sophisticated product, requiring contemporary innovative management methodologies, matched by adequate design information. Even so, success can be elusive through the nature of the variability of the product, its environment and the degree of its complexity’. According to Cooke (2013) the modern construction project uses a multidiscipline approach of design professionals from engineering, architecture to finance and legal professionals which introduces a level of complexity. Concluding Cooke (2013: 8) states that the ‘question is, can advances in technology (along with our increased knowledge of complexity and its impact) actually assist in reducing the “complexity of projects”? 

Continuing the debate on complexity and uncertainty Skitmore, Stradling and Tuohy (1989: 103) discuss project uncertainty and the construction industry. By way of introduction to their paper Skitmore et al (1989: 103) write ‘the influence of uncertainty in the construction industry, and of the risks generated by such uncertainty, has been of increasing concern over the decades since the report of the Tavistock Institute in 1966. Awareness that uncertainty does indeed lie at the heart of many industries organisational problems suggests that research in this direction is a priority.’

Skitmore et al (1986: 105) reviewed some of the biases of information that can lead to uncertainty; ‘Human judgement is generally subject to systematic error or biases as well as subject to unsystematic error, or variance. In the evolutionary context such judgmental biases were adaptive, providing cognitive shortcuts.’ Skitmore et al (1989: 105) identify the four stages at which the biases can interact with the project call for information:

<table>
<thead>
<tr>
<th>Stage one: Biases in the acquisition of information, typically the recency or strikingness of information.</th>
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<tbody>
<tr>
<td>Stage two: Biases in the processing of information, the mental processes applied to the information once it has been recalled.</td>
</tr>
<tr>
<td>Stage three: Biases in output processes, biases can result from the format of the required judgement.</td>
</tr>
<tr>
<td>Stage four: Biases in feedback processes, the aspects of judgement, where we learn from experience.</td>
</tr>
</tbody>
</table>

Continuing the discussion on complexity of project management in construction projects Jallow, Demain, Baldwin and Anumba (2014) investigates the arrival at a better approach to managing the complexity of client requirement in construction projects. The results of Jallow et al (2014)
highlight factors associated with the complexity of managing client information requirements, which include: ‘mechanisms for documentation storage and access, distribution of requirements information between stakeholders and across lifecycle phases of a project, traceability management and the provision of effective change management incorporating dependency checking and impact analysis’. Jallow et al (2014) identified that a better approach was required regarding the management of information to facilitate the completion of projects within budget and on time.

Discussing project uncertainty Cates and Mollaghasemi (2007: 3) state that ‘uncertainty is present in many places including the estimates for activity durations, in the occurrence of unplanned events and in the availability of critical resources.’

This is prevalent in the large multidiscipline mining project and the outcome is the inevitable delays, cost increases and the dilution of the benefit to the stakeholder.

In the real world of projects Andrew (2011) states ‘Mathematical means of operating under uncertainty to achieve some goal are usually devised and justified without reference to the underlying causes of uncertainty. The methods are meant to have general applicability and so to be rather insensitive to the nature of these underlying causes’. Andrew (2011: 112-113) introducing his theory states ‘To explain why the world is best seen as grey or uncertain, it is first necessary to ask why its future is not effectively black or totally unknown. If by “knowing” we mean “knowing with certainty” then the future is indeed unknown. All behaviour that can be classed as adaptive or learned, including all science and anything that is in any way goal-directed, depends on an assumption that the future will have certain similarities to the past’.

By way of contrast Andrew (2011: 113) discusses that there are several ways in which uncertainty can arise and the emergence of chaos theory which shows that many systems are basically unpredictable even though their interactions at some level are determinable and understood.

Karlsen (2009: 642) examines the critical role of the project owner, or project sponsor in uncertainty management. From Karlsen (2009: 642) ‘The project owner and steering group involvement in the project’s uncertainty management process were identified’. ‘The results indicate that this has reduced the asymmetric information problem between the parties. This involvement has also contributed to building a collaborative, respectful, professional and trusting relationship between the parties. Another effect that was found is that the project owner has learned about uncertainty management and developed uncertainty consciousness’.

Clearly the client or project owner has to become involved in the process of uncertainty management and that this improves and expedites the design process and assures better decisions. Communication is one of the keys to project success; this becomes more so on large projects with a resident high degree of uncertainty and complexity. It is necessary to ensure that
all parties are kept informed of the project progress and that real inputs are sought from these parties.

For Karlsen (2009: 644) the project owner is the key stakeholder, in his context the project owner is the investor, provides resources and direction as required. From Karlsen (2009: 644) ‘Uncertainty consciousness is the development of a viewpoint that continually examines how uncertainty may occur and what its impact might be. Uncertainty consciousness has to flow from the top throughout the organisation; the project owners must have this consciousness and they must constantly communicate the need for it to all project managers and teams’.

Assuming this role can be a technical challenge for some project owners; Karlsen (2009: 644) states that this is where the project steering group can become the owner’s representative. In addition Karlsen (2009: 644) states it beneficial to establish a project steering group to represent the project owner, specifically in large projects and when there are several owners involved. This group should be; committed to a successful project outcome, able to make decisions, able to provide resources, and be experts in their field. The selection and delegation of the project steering group needs to be carefully reviewed and accepted this has to be understood by the project manager. For Karlsen (2009: 645), ‘The importance of uncertainty management for project success is not disputed. All projects are exposed to uncertainty – from the first initiation to delivery and implementation’.

Risk and uncertainty to a certain extent go hand in hand, from Karlsen (2009: 645) ‘Distinguishes between risk and uncertainty in the following way: risk is said to exist in situations where each outcome has a known probability of occurrence, whereas uncertainty arises where the probability of the outcome of events is unknown’. ‘Never the less uncertainty has to be seen as being an integral part of project management on large multidiscipline mining projects and steps have to be taken to address this to the benefit of the managing company and the client’. Uncertainty management should therefore be treated as a specific process by itself.

Under uncertainty communication there is a need to involve the client in the resolution of the uncertainty. Uncertainty communication according to Karlsen (2009) is an integral component of the uncertainty management. From Karlsen (2009: 647) the management of uncertainty was often only practised within the managing party, ‘This internal project communication approach has changed in some firms because they have understood that it is a mistake for effective uncertainty management to ignore or not involve the project owner or other project stakeholders’.

From Karlsen (2009: 648), ‘It is a general view that collaboration and working closely together are beneficial for both the project and the firm’. ‘Failing to collaborate can result in the distortion of information, which, in turn, can lead to costly inefficiencies’.

Karlsen (2009) refers to the aspect of ‘asymmetric information’. This is a critical aspect to address within the large multidiscipline mining project. For Karlsen (2009: 648) ‘there is an information
asymmetry between the project managers and the project owners that creates the potential for mistrust’. Asymmetric information is therefore a significant challenge to address where the relationship with the client or project owner is seen to be unbalanced or adversarial.

Karlsen (2009) continues discussing the necessary for the project owner and the project management team participate equally in the uncertainty management process. Karlsen (2009) confirms that results show that project owner and the project execution group participation in the uncertainty management process and the communication and sharing of uncertainty information and knowledge, creates positive effects:

A supportive uncertainty management culture.

Building a collaborative, respectful, professional and trusting relationship.

Learning about uncertainty management and developing an uncertainty awareness.

Establishing uncertainty information database to help the owner and the project management group to develop a holistic project view and processes for improved decisions.

The project owner representative states that the sharing of uncertainty information functions as a control mechanism.

Uncertainty information and knowledge sharing have, according to the project manager, forced his project team to perform a more thorough and systematic assessment of uncertainties.

Moreover, he underlines that the sharing of uncertainty information and knowledge has created valuable and learning discussions among the project participants.

Karlsen (2009: 657) continues stating, ‘the research results indicate several interesting effects:

The project owner and steering group commitment to the uncertainty management process and exchange of uncertainty information have contributed to the development of a supportive uncertainty management culture.

The project owner and steering group participation in the uncertainty management process have increased their knowledge about uncertainty management and their uncertainty consciousness.

The data shows that by receiving uncertainty reports and discussing uncertainties, the project owner and the steering group have been able to create a more holistic view of the project and its processes for improved decisions’.

Expanding on the topic of the culture of uncertainty management Karlsen (2011: 240) develops the premise that there is uncertainty in project management and reviews the effect of the company culture on the effectiveness of uncertainty management.

Karlsen (2011: 240) found that, ‘a supportive uncertainty management culture is characterised by: positive attitude, commitment of time and resources, openness and respect, understanding of uncertainty management, uncertainty management internalised into daily work, senior managers asking for and using uncertainty information, proactive uncertainty management, a focus on
opportunities, clear areas of responsibility, accepted and operationalised policy and terminology, and a holistic uncertainty view'.

Karlsen (2011: 240) states that project managers are faced with ever-increasing challenges and complexity. ‘This is due to the fast changing business environment in which projects are typically carried out, but also because of the changing nature of the projects themselves’. ‘Many managers are under enormous pressure to complete complex and uncertain tasks in the shortest amount of time without sacrificing the cost and quality criteria or leaving the customers and end-users dissatisfied’. It could be said that the certainty in project management is the uncertainty, the ability to be able to control and manage the uncertainty to the benefit of the project is essential.

Karlsen (2011) reflects on the frequent event of project failure where projects fail to meet expectations and where they run over budget, are late and under perform. The result of this is that the client does not receive the expected benefit from the timely project completion. Karlsen (2011: 241) states, ‘This is often the result, despite the application of uncertainty management tools, techniques, and processes. Owing to its importance, one would expect project uncertainty management practice to generate a large effect. However, some recent studies have raised a concern regarding the effectiveness of uncertainty management tools in a project environment’.

The project managing organisation would therefore need to develop, entrench and practise uncertainty management tools and skills in order to be able to guide the project through the period of uncertainty.

In reviewing uncertainty management maturity Karlsen (2011: 242) on the four attributes of; processes, application, experience and culture. Firstly under processes, there has been much activity in the past few years to generate processes to more effectively deal with the uncertainty aspect of project management. Reflecting on previous authors on this topic Karlsen (2011: 242) recalls the four major stages of the uncertainty management process:

| Uncertainty management planning, |
| Uncertainty identification, |
| Uncertainty analysis, |
| Uncertainty response. |

The second aspect of uncertainty management maturity is application. In this aspect Karlsen (2011: 242) reflects on the consistent application of the uncertainty management processes and the complimentary tools to support the process of identifying and quantifying the uncertainty.

The third aspect of uncertainty management is experience. The experience in uncertainty management develops a body of knowledge within the organisation. Karlsen (2011) places particular emphasis on the development of the body of knowledge for the organisation and stresses that this is a core strength and the foundation of uncertainty management.
The fourth aspect of uncertainty management is organisational culture. According to Karlsen (2011: 243) there has been a great deal written about organisational culture. Despite the quantity of literature the concept of organisational culture is difficult to define. Probably the closest definition of culture proposed by Karlsen is the shared values of an organisation; values, beliefs, practices, rituals and customs.

How does this transpose into a project management culture?

According to Karlsen (2011: 243) to a certain extent the project management culture would have to reflect the culture of the recipient client organisation. Karlsen (2011: 245) quotes authors in stating, ‘culture is widely understood as an instrument to be used by management to shape and control in some way the belief, understandings, and behaviour modes of individuals, and thus the organisation to reach specified goals’. To Karlsen (2011: 245) the operational dimension of organisational culture by defining it as “the way we do things around here”. For Karlsen (2011: 246):

- The company must have a positive attitude to uncertainty management; this attitude has to flow from the top of the organisation.
- The company has to commit time and resources to uncertainty management, with the long duration engineering projects and in the mining industry uncertainty is prevalent.
- The third aspect is the aspect of openness and respect, what is essential in the organisation is the tolerance for bad risks.

Karlsen (2011: 247) raises the discussion of problematic issues and the raising of risk issues should be encouraged and rewarded.

It is essential the uncertainty management must be understood, Karlsen (2011: 248) states, ‘a lack of understanding for uncertainty management makes it difficult to create and discuss a real project picture’. All persons within the project execution team must understand and practise the principles of uncertainty management.

The entrenchment of uncertainty management must be complete and practised on a daily basis. Karlsen (2011: 248) quotes, ‘we try to incorporate uncertainty management into the project’s daily work, for example, by encouraging project managers and team members to think in terms of uncertainties when they are planning, organising, making decisions, etc.’. Karlsen (2011: 248) is convinced that uncertainty management has to be integrated into the daily activities and become part of the culture. Senior management must become involved in the daily uncertainty management processes of the company across all of the projects. This can be in the form of a calling for and a review of uncertainty reports.

As in any project management environment there is a necessity to look for opportunities and to monopolise on challenges. According to Karlsen (2011: 249) ‘the majority of project managers tend to concentrate almost exclusively on the negative effects of uncertainties’. ‘The result of this
"focus is that opportunities tend to be overlooked". ‘The existing uncertainty management processes cannot be said to be fully able to manage opportunities’. As uncertainty appears to be a feature of long term engineering projects then this has to be accommodated in order to be successful. Therefore, it is essential to be able to convert the threats that uncertainty generates into opportunities.

According to Karlsen (2011: 249) it is necessary to assign clear responsibilities for uncertainty management. As Karlsen (2011) states, ‘the responsibility must be clearly defined and understood by those it applies for, for example, what to do, what to communicate, which reports to be made, etc. The responsibility must be followed up and reviewed, not only allocated’. ‘Another tool which can help to define and clarify the responsibilities for uncertainty management is a responsibility chart.’

According to Karlsen (2011: 250) ‘one of the management challenges is to build a supportive culture for ensuring that everybody with uncertainty management responsibility feels confident raising, discussing, and managing uncertainties.’ ‘Many have often spoken about having an uncertainty management culture, when they should have spoken about building a supportive culture’. ‘A good culture for effective uncertainty management is something that must be developed over time’.

In figure 2.1 below Karlsen (2011: 251) demonstrates the interrelationship between uncertainty management culture tools.

![Figure 2.1 - Uncertainty management culture tools: derived from Karlsen (2011: 251)](image)

Developing the uncertainty management culture tool Karlsen (2011: 251) found that the most important catalyst is the effective and open communication model where individuals are
encouraged to be open and forthright. Karlsen (2011: 252) stated that, ‘it is vital to focus on the cultural dimension when introducing and developing uncertainty management in projects’.

In conclusion Karlsen (2011: 253) states, ‘Project-oriented organisations which seek effective uncertainty management need personnel with a positive attitude to uncertainty management and personnel who are willing to think uncertainty and integrate it into daily work practice’. ‘The purpose of paying attention to these aspects in addition to the uncertainty process is to develop uncertainty maturity within an organisation and among its personnel’. ‘This represents a situation where all the necessary pieces are in place to allow uncertainties to be managed proactively and effectively, with a supportive culture, efficient processes, experienced personnel, and consistent application’.

Asslani and Ettkin (2007: 31) discuss project uncertainty in the IT project environment; their philosophy is commutable to the large multidiscipline mining project environment. Asslani and Ettkin (2007: 31) state that ‘because of dynamic, complex and competitive environments, many information technology (IT) projects are plagued by significant cost overruns and unexpected schedule slips’. ‘Research suggests that a major reason for project failures is management’s inability to address uncertainty during the development of a new management information system.’

Though some of the drivers of uncertainty may differ the controls could be assumed similar. Many large multidiscipline mining projects start with the project definition incomplete.

Asslani and Ettkin (2007: 43) conclude their discussion thus, ‘Uncertainty management remains a major concern for the successful implementation of projects. While existing literature identifies major project risk factors, this paper uses those factors as a starting point to offer three entropy-based measures of project uncertainty. These measurements are based on the theory of information, uncertainty, and project development risks’.

Though not directly transferrable, uncertainty requires careful consideration both to manage and to mitigate.

Cates and Mollaghasemi (2007: 3) give importance to increasing the visibility of the project uncertainty to increase stakeholder awareness of the effect of this uncertainty. Further from Cates and Mollaghasemi (2007: 9) there is a great reliance on historical data regarding such items and using the simple techniques described the project management house can demonstrate greater success in the implementation phase. The Engineering Manager can be in a position to identify the current status of the project and the risks to completion. They suggest the development of a project assessment simulation model that does not just add in time for each activity as this would tend to make the bid uncompetitive. They recommend planning a project so that it remains on schedule, a risk balanced project with a realistic buffer, this should be applied to the large multidiscipline mining project.
Events and improvements in the understanding may have overtaken the thinking of Cates and Mollaghasemi (2007). The paper does not seem to develop theories over what is expected of a skilled project planner.

However according to Ford and Bhargav (2006: 275) ‘Flexible strategies in the form of options can increase project value if uncertain conditions cannot be adequately forecast before operations begin’, a scenario that could apply to the large multidiscipline mining project. Ford and Bhargav (2006: 275) acknowledge the uncertainty of the future scenarios for the project in execution. In order to address this, they suggest, ‘Flexibility and generativity are two approaches for successfully addressing uncertain future project conditions’. ‘Flexibility and generativity are primarily distinguished by whether the risk management occurs while the uncertain conditions evolve (generativity) or precedes the uncertain processes (flexibility)’. Ford and Bhargav (2006: 276) state, ‘Increased pressure to complete projects faster, cheaper, and better and competition from other firms have increased the need for project strategies and management that can effectively manage project risk’.

Ford and Bhargav (2006: 286) conclude by stating, ‘an operations perspective can be applied to project management as well as to operations strategy’. ‘The use of intermediate and good resource allocation can be seen as options to improve project management relative to poor resource allocation’. ‘This could take the form of a change in managers or a project manager training program.’ The EPCM Company should be aware of the options to change the management team during the project execution.

Hällgren and Maaninen-Olsson (2009: 53) endeavour to ‘contribute to the understanding of how unexpected events (deviations) are handled and how the limited time available in a project affects the possibilities for reflection and knowledge creation.’

Hällgren and Maaninen-Olsson (2009: 53) describe the findings of their research thus, ‘the management of deviations was found to be primarily informal’. Two reasons were identified.

- ‘First, insufficient time for formal procedures’.
- ‘Second, if the formal routines were to be followed, the window of opportunity would be lost, making the decisions that follow useless’.

Clearly there is room for additional research in this area, the findings of Hällgren and Maaninen-Olsson (2009) may not be strictly true in all aspects of project management. There could be a tendency however to deviate from the formal processes of the company when there is minimal time available and the overall project program is under threat.

For Hällgren and Maaninen-Olsson (2009: 64) deviations are inevitable and the project has to adapt. ‘Despite the effort that is put into reducing the number of deviating events they remain very expensive for projects. These changes and risks are commonly treated as what should be done rather than what is done.’ Further according to Hällgren and Maaninen-Olsson (2009: 64) time
limitations often prevent the use of formal process tools in the EPCM structures. ‘The time limitation not only affects the control methods, but also how a deviation is reflected upon. The lack of time influences the opportunities for both individual and collective reflection.’

Clearly this is not ideal and where the client has appointed an EPCM Company to the role of managing the project this could have a direct effect on the reputation of the company and the profitability of the activity.

Yim, Castenada, Doolen, Tumer and Malak (2013: 979) discuss the premise that ‘engineering systems design projects require the integration of multiple technical systems’. These processes require a range of engineering disciplines; a similar team construct as to that required by large scale engineering projects. Yim et al (2013) discuss the identification of risk indicators through the presence of functional complexity. This would be another internal risk where the risk is developed from an internal complexity with the EPCM Company.

As an introduction Yim et al (2013: 979) state that ‘Engineering design companies undertake a multitude of projects each year ranging in size and scope. Allocating money, time, and resources to meet the needs of each project requires a great deal of effort and planning’. In this study there was a review of the complexity and risk introduced by the number of functional departments involved in the project execution and the risk induced by this in the project execution.

According to Yim et al (2013) as we have seen before, the earlier a risk can be identified the earlier it can be addressed and the greater the opportunity for a successful project execution.

According to Yim et al (2013: 980) as projects become more complex, the project management practices must become more comprehensive and tailored to the characteristics of individual projects. This follows the philosophy of a flexible ‘custom-made’ project management program for the large multidiscipline mining project. Additionally risk and uncertainty is more likely, and effective project management becomes more critical. Yim et al (2013) describe a complexity frame work as falling to four elements:

- Project system size,
- Project system variety,
- Interdependencies within the project system,
- Elements of Context.

These complexity elements discussed here are expanded in the table 2.5 below.
Table 2.5: Complexity framework derived from Yim et al (2013)

<table>
<thead>
<tr>
<th>System size</th>
<th>System variety</th>
<th>Interdependencies within the project</th>
<th>Elements of context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
<td>Diversity and variety of project elements</td>
<td>Sharing resources, people, and materials</td>
<td>The competition</td>
</tr>
<tr>
<td>Size of the budget</td>
<td>Organisational interdependencies</td>
<td>Coordinating schedules</td>
<td>Cultural context</td>
</tr>
<tr>
<td>Duration of the project</td>
<td>Experience and skill sets of the staff</td>
<td>Interdependence between objectives, project phases, team cooperation, and communication</td>
<td>Environmental complexity</td>
</tr>
<tr>
<td>The number of deliverables</td>
<td>Variety of financial resources</td>
<td></td>
<td>Local and international laws and regulations</td>
</tr>
<tr>
<td>Departments involved</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hierarchical levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information systems</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It can be seen that many of the complexity issues affecting the project are within the control of the EPCM Company and outside the immediate control of the client.

Yim et al (2013) conclude from this study that ‘in engineering design projects engaging multiple functional groups, changes made by one functional department inevitably impact the work activities of other functions’. Further that ‘close communication and collaboration are necessary to avoid projects falling victim to schedule delays, cost overruns, and scope creep’. ‘Risks stemming from inadequate documents and standard procedures were also prevalent, regardless of the number of functional groups engaged in the project’.

Gil, Tommelein and Beckman (2004: 1) in their paper titled ‘Postponing design process in unpredictable environments’ suggest that there is evidence that delaying critical decisions until as late as possible can reduce time to market and reduce the effect of uncertainty.

Though Gil et al (2004) are discussing the semiconductor development process the philosophy is easily transferrable to the delivery of large multidiscipline mining project. Detail design is expensive and resource consuming, so where there is uncertainty as to the client’s requirement it would not be beneficial to undertake detailed design. They discuss a flexible model for product development that allows for an implementation phase that overlaps a concept development. This would be transferrable to the large multidiscipline mining project where the designer can work on the known aspects of the package or identify items from previous projects that can be reused.

Where the implementation lead time can be overlapped with the design lead time to a greater extent than the completion date could be maintained even with a design commencement delay.
Ochieng, Proce, Ruan, Egbu and Moore (2013) discuss the complexity challenge to the project manager introduced by the necessity of managing cross cultural teams. They state that ‘The continual need for improved speed, cost, quality, safety, together with technological advances, environmental issues and fragmentation throughout the construction industry’, have contributed to the growing complexity of construction project. According to Ochieng et al (2013) the management of complexity in project is of increasing concern and the few studies that have explored the subject have only done so in general terms.

Ochieng et al (2013) review the impact of cultural differences, formal and informal values in the contracting groups that introduce uncertainty into the project in execution. Ochieng et al (2013) write against the background of project execution in Kenya where the socio-economic stress is particularly apparent. Ochieng et al (2013: 309) state that regarding multiculturalism ‘very few empirical studies have been undertaken on its role in construction project management. It could therefore be suggested that any construction project where contractors bring different assumptions about working norms (either in design engineering or team behaviour) is a multicultural project. Even when all contractors are from one country, the construction project manager may still have to deal with cultural diversity’. Ochieng et al (2013) reflect on the need for effective communication and that managing a multicultural team presents new challenges to the project manager particularly with regard to the development of an understanding of the cultures and attitudes. Managing the cultural differences can lead to the success or failure of the construction company. Ochieng et al (2013: 309) state that ‘Every multinational construction organisation has a strategic choice in how it will face this challenge: whether to adopt a fundamentally defensive approach, or one that develops the individual and the group’. The following aspects identified in previous literature according the Ochieng (2013: 311) as being key to establishing best project execution practices:

| Standardisation of procedures and methodologies, |
| Efficient interface management, |
| Ethical actions, |
| Communication between government and contractors, |
| Attention to organisation culture, |
| Government understanding of the construction industry, |
| Recognition of location differences in language, terminology and cultural standards. |

Ochieng (2013) discuss the nature of projects is that there will be construction teams from various locations, this introduces cross cultural complexity.

From Ochieng (2013: 321) for managing cross-cultural complexity the project manager must:
Be able to understand the type of leadership style preferred by the multicultural project team so that authority is respected.

Set up a supportive and positive project culture.

Be fair and consistent when dealing with project team members.

Albrecht and Spang (2014) determined the benefits of company project management maturity in dealing with the complexity of projects. They state that the complexity of projects might be a determining factor regarding the “ideal” level of project management maturity. A comparison of the findings on project complexity showed that those aspects of project complexity that affect the interaction of the project stakeholders seem to require a level of maturity. This would be particularly relevant to the execution of complex projects in the mining industry.

Albrecht and Spang (2014) say that the models for project management are increasing in optimisation and sophistication. The developers of these models suggest that there is more and more maturity in these models, the premise is that the greater maturity assures greater success. Abrecht and Spang (2014: 287) define the level of maturity as ‘depicted by a number (e.g. five) of maturity levels or expressed as a percentage’. ‘The lowest level represents informal or “ad hoc” project management, while with higher levels of maturity the project management structures will be documented, formalised and continuously improved’. Albrecht and Spang (2014) identify the following aspects as measures of maturity:

- Project management entrenched in the organisation structure,
- Project support from top management,
- Personnel development focused on project management activities,
- Use of appropriate project management software,
- Application of project management software.

Comparing with previous authors Albrecht and Spang (2014) reflect on the metrics for project complexity as being; the team size, the dispersion of the team, the working history of the team members, and the number of internal and external interfaces.

Albrecht and Spang (2014) surmised that the complexity of the project determined the need for formalisation and hence maturity.

As a mitigating process Gil, Tommelein and Ballard (2004) in their paper look at novel techniques for project delivery in semiconductor fabrication. The techniques proposed though developed in that environment could be transferrable to the large multidiscipline project environment, they state ‘in unpredictable project environments, environments in which design criteria are likely to change irrespectively the project progress status, simulation reveals that the averages of construction rework and waste increase if design is prematurely frozen.’
Gil et al (2004: 2) discuss the benefits that can be accrued by the early involvement of the specialist contractor particularly if they are involved in the early design processes. They also state the specialist contractor is also involved in the detail design of the systems and in the system maintenance. Typically, in the large multidiscipline mining project the specialist may become involved in the design of pumping systems and in the design of conveyor systems amongst other plant elements.

Specialist suppliers could be willing to commit resources in assisting the EPCM Company in specifying the equipment required for the specific installation, greater involvement would certainly require the commitment of the client to a contract. This is described by Gil et al (2004: 13) as the competitively bid specialist contractor.

Clearly the early involvement of the specialist contractor has distinct advantages; the design phase of the package can be reduced hence permitting the absorption of the delays in the design finalisation.

Discussing the concept of project WBS granularity Verveniotis (2008: 2-1) states, the ‘structuring of mega-projects for effective project control can be as much art as science, and is influenced by many factors’. Excessive WBS breakdown would cause unnecessary cost to project administration with little benefit to project outcome. The cost engineer’s challenge is designing the balance between coding and visibility for the most cost-effective management. ‘Granularity influences include project physicality, number of design entities, contract strategies, and procurement methodology’.

Verveniotis (2008: 2-2) discusses at some depth the creation of the WBS, this is usually unique to the project and the discretion of the project management team. When this is applied to the large multidiscipline mining project how does the WBS change? ‘The size and uniqueness of megaprojects will nearly always pull together a project execution team that has not previously worked together, this will always challenge the cost engineer that is tasked with developing the WBS for the megaproject’. ‘The cost engineer can promote efficiencies by recommending the minimum set of WBS codes that satisfy the risk tolerance’. As the large multidisciplinary mining project is divided into smaller projects, a cross section of all of the projects must be examined to develop a structure that is common across all work. Other WBS elements can be created that relate to only certain projects, with the understanding that the details will be lost across the large multidisciplinary mining project.

Verveniotis (2008: 2-2) also reflects on the effect of the complex mix of the project players on the definition of the WBS; ‘The reporting requirements of each company will be different, and the number of major entities will challenge even the most creative cost engineering team to devise a WBS that will satisfy everyone. The early stages of the project definition must include an aggressive approach to minimise the impact of preferential reporting needs’.
In conclusion Verveniotis (2008) states that there is no standard for the WBS coding to be used on the project rather to have a project specific WBS and that there is a diminishing return on the level of detail in the WBS coding. Efforts must be made to resist the urge to define the WBS where there is no clear work element. The large multidiscipline mining project would be split into convenient work packages but would be tied into a main project program for the completed and commissioned mining facility.

For Verveniotis (2008: 2-5) devising a WBS on large projects is as much art as science, but the large project does not inherently cause a larger WBS. ‘Once the megaproject is divided into manageable subprojects, a standardised WBS allows effective reporting across the entire megaproject for all players’.

Complexity and uncertainty in project execution is one of the more significant aspects requiring the attention of the project leadership team. The complexity of the project can have many drivers not lease of which would be the drivers from the project is self. Apart from the aspects of project size and project interdependencies the leadership may be required to manage the cultural and regional complexities of the project team and stakeholder groups.

Through the application of specific project tools and working within a supportive project environment the project leadership and thus the project team will be in a better position to manage the complexity and uncertainty.

2.8 Project gaps

The management of project gaps is a fundamental responsibility of the EPCM company. A project gap could be seen as being a an aspect of uncertainty.

Gap analysis has been well researched in current literature, the following article however discuss specifically the gap analysis approach to improve the management of a project.

Winch, Usmani, and Edkins (1998) discuss the aspect of quality management and ‘place minimisation of client surprise’ at the heart of the assessment of project successes. Winch et al (1998) reflect on the cathedral and the papal palace of Pienza at its hand over. ‘Clients expect to pay what they had originally agreed to pay, the building to function as they want it to function and for it to be ready when they need it. A surprised client is a dissatisfied client’. This is as true now as it was then.

Winch et al (1998) discuss the project management processes of their era as rarely placing the client at the centre of the process and that they rarely consider the project as an entity. Winch et al (1998) take this criticism further ‘our approach to project management is both inherently fragmented and orientated towards the needs of the producers in the project coalition rather than the client’. They put forward the need to take a wide view of the project delivery; citing a focus on
quality assurance and audit, design management, site operations, engineering design whilst missing the necessity to consider all aspects of the project.

Winch et al (1998), reviewed the existing literature, highlighting the then problem of focusing on the needs of the producers scarcely highlighting the needs of the client. They state obviously that what is required is an orientation towards delivering client satisfaction, not deciding liability once the client is dissatisfied. Not finding the required insight from the construction texts the referred to the service quality management texts. They refer to authors of the period when discussing the Gap Analysis approach.

Winch et al (1998:194) identified and discuss the five principal gaps:

<table>
<thead>
<tr>
<th>Gap 1: between client expectations and management's perceptions of client expectations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gap 2: between management's perceptions of client expectations and management's translation of those perceptions into service quality specifications.</td>
</tr>
<tr>
<td>Gap 3: between service quality specifications and actual service delivery.</td>
</tr>
<tr>
<td>Gap 4: between actual service delivery and the external communication to the client about the service.</td>
</tr>
<tr>
<td>Gap 5: between actual service delivery and the client's perception of the service.</td>
</tr>
</tbody>
</table>

The gap identification process tabled by Winch et al (1998) is concerned about the client’s views from the start of the process to the completion of the process and the delivery of the completed project to the client.

Winch et al (1998: 195) take time to review the nature of the construction project. They reflected on the necessity for the flow of information linking this aspect to communication, and the flow of material against specification, to site. The authors reflect that at inception of the project little is known about the configuration of the project at its conclusion, this could be seen as being clearly analogous to any large multidiscipline mining project. At this point Winch et al (1998) reflect on the screens through which the information has to flow, initially the issue is to maximise the exploration of options, at mid-term the problem is to choose clearly and decisively thereby freezing the project and in the execution phase the objective is to mobilise as quickly as possible due to convert the significant financial investment.

Here there is a clear difference to the large multidiscipline mining project as different aspects of the project could be in different fundamental project phases at the same point in time. However the management of gaps is primarily base on of effective communication and agreement on expectations. The flow of information on scopes and specifications, progress, technical decisions and the program performance must be precise and in good time.
2.9 Project crisis

In execution a project can be affected with project crises, the crisis can be in many forms but how the crisis is managed by the project leadership will determine the effect of the crisis on the final delivery of the project. This section of the literature review examines one article that discusses project crisis management.

Hällgren and Wilson (2011: 196) wrote that crises should be seen as being valuable events where learning aspects can be found and converted in to benefits for the project team. According to Hällgren and Wilson (2011: 196) the founders of Google are attributed with the saying ‘A crisis is a terrible thing to waste’. Within the ever changing environment of a large multidiscipline mining project there will be many crises; be it in terms of time, cost, quality or safety, each of these events can be seen to be a learning point for the future.

In terms of time and cost the projects that are easier to define more completely are those that are less likely to be confronted by crises in the execution phase, on the contrary projects that are less easy to define are more likely to be confronted by crises.

Hällgren and Wilson (2011) highlight the following that crises can be resolved with four actions: mobilisation, prioritisation, normalisation and responsibility. These are coupled to the seven organisational practices: the initial call, maintenance of calm, assessment of the situation, assignment of responsibility, temporary permanency or acceptance, response team mobilisation and debriefings. Hällgren and Wilson (2011: 209) review case studies and develop the cue and response theorem with the following four typical responses:

Mobilisation: Mobilisation refers to the practice of raising the necessary resources within the organisation in order to develop a joint appreciation of the crises. To resolve the crisis the crisis needs to be understood in a common way. The common understanding is required in order to achieve a common agreed solution. Clearly there is a necessity to gain a common appreciation of the crisis and to agree on a standard solution to the problem. The organisation can identify subject matter experts and deploy these persons to assist in the development of a solution to the crisis.

Prioritisation: The process of making one task more important than another. This will also involve the process of defining the tasks and allocating resources for completion. In the project environment this will also involve the reallocation of project execution staff.

Normalisation: The process of making the crisis something normal for the team to execute and above all controllable. The goals for the project may need to be renegotiated. Within this process is the gaining from the client that the crisis is under control and that there is no case for further dispute.

Responsibility: The process of shifting internal or external organisational accountability, when tasks and consequences are assigned to sub-contractors or clients. When the project team carries overall responsibility, these responsibilities are shared. Commonly,
the features of the responsibility structures are formally documented the contracts among organisations.

Hällgren and Wilson (2011: 212) give advice in respect of the handling of the project crisis.

The initial call: the initial call starts the clock running and sets the scene in which the crisis will be situated. The initial call also gives the caller the opportunity to define the crisis. The efforts of the response team can thus be focussed on the resolution of the crisis and not on the prevarications of crisis definition.

| Maintenance of relative calmness: Any surprise or alarm must be contained and focussed on the affected project or aspect of the project. In addition to this the crisis must be seen to be handled professionally. The crisis must be handled calmly and the personnel involved must conduct their business in a professional manner. |
| Assessment of the situation and assignment of responsibility: The situation must be assessed prior to the development of a response and the allocation of responsibilities. |
| Temporary permanency and crisis response teams: In dealing with the crisis the organisation can respond with either a project team response or with a crisis response team. Either approach can be effective. Dependent on the skills resident in the project team, the project team would have the best understanding of the client's need and response pattern. The use of the project team would also ensure the response is project sympathetic and the learnings are retained in the team. |
| Debriefings: Debriefings are thought to be the most effective means of ensuring the learnings are captured in the organisation or across the project team. They allow a dispassionate review of the situation and to put the various project aspects into focus. |

A crisis only becomes a crisis if the response of the EPCM company allows it to become a crisis. The project team has to be aware of developing crises, and ready to respond. The project leadership has to have established plans for the detection and management of project crises and the response has to ensure the crisis is measured, communicated, met, managed, reported and learned from.

2.10 Project failure

Should the project crisis materialise then there is a risk that project failure in some facet may follow. In this section of the literature review the pervasiveness, definitions and occurrences of project failures are examined.

Lawrence and Scanlon (2007: 511) quote scathingly from the Harvard Review thus; ‘Big projects fail at an astonishing rate - be this; major technology installations, post-merger integrations, or new growth strategies, these efforts consume tremendous resources over months or even years’. Projects frequently deliver poor returns - by some estimates, in fact, well over half the time, and
the toll they take is not just financial, ‘these failures demoralise employees who have laboured diligently to complete their share of the work’. According to Lawrence and Scanlon (2007: 512) the scale of failure suggests that the problems are universal. The vast majority of the individuals managing projects are well qualified, well trained and highly committed. Therefore, the percentage of programme failures clearly suggests a cause outside competence.

Though the thought of a failure outside human competence is a stretch, what is this fundamental failure mechanism they are alluding to?

Lawrence and Scanlon (2007: 512) refer to the idea that a significant weakness in large engineering projects today are the programme management and planning tools that are being deployed. ‘In essence, the underlying methodology and philosophy of these tools has not changed a great deal in 50 years’. In their writing Lawrence and Scanlon (2007: 516) focus to a large extent on the aviation industry but the following comment can be related to, ‘Project planning can be defined as ‘The mapping of future events to time to describe how, when, by whom and what with a specific target, or set of targets, is to be achieved”’. Such planning is critical to successful projects and requires much interdisciplinary and concurrent working. Co-operation across engineering teams and project managers is vital to the planning process.

Lawrence and Scanlon (2007: 519) state that ‘Our research in the aerospace and defence field has shown that managers often become reluctant to carry out detailed planning using existing planning tools because they find it an unrewarding and labour intensive activity’. They continue by stating that ‘This is primarily because existing tools cannot adequately represent the detailed information flows and iterative dependencies that are typical of real projects. Resource requirement estimates are often seen as entirely notional, with the highly negative consequence that the estimating process is not taken seriously enough.’

As Lawrence and Scanlon (2007: 519) describe the situation as translation ‘as the plan is literally not a sufficiently accurate model of reality’. The complexities of the project are changed and simplified so that they can fit into the planning software. ‘The plan is no longer a true reflection of the actual and there is an increasing divergence between the plan and the project’. Lawrence and Scanlon (2007: 520) are of the opinion that the planning software should not have any limitations as to capability.

Moving further into the project failure causes Lawrence and Scanlon (2007: 521) discuss the process of understanding the project dependencies. ‘The lack of a clear understanding of project dependencies is a key cause of project failure in complex, highly distributed engineering projects, where engineering judgement or intelligent guesswork is just not sufficient’. They continue stating large projects are problematic because they have become obscure to those managing them. In large multidiscipline mining project, the dependencies can be many and diverse and sometimes
only appear after time. Excavations have to be sized long before the equipment required to occupy the space has been fully defined let alone ordered.

Lawrence and Scanlon (2007: 521) reviewed the resource allocation practices within the industry they are familiar with. There are clearly problems regarding resource allocation. ‘Existing planning tools often underestimate resource requirements because: they cannot model iterations and feedback loops and therefore do not account for the necessary repetition of key activities, which can miss important detail’.

As is very common in the execution of the project there will be inevitable changes to the scope of the project which could be brought about by a variety of factors. Lawrence and Scanlon (2007: 522) see this as a cause of project instability. ‘Irrespective of the quality of planning undertaken, it is almost inevitable that projects will deviate from the original plan due to a change in objectives or customer requirements’. Thus without a well-structured project plan with clearly identified dependencies changes will not be captured and linked to the main plan quickly and effectively.

Again this is a common feature of the large multidiscipline mining project, in the time it takes to execute the project and the changes in project execution team there will be many changes to the scope, some will be more significant than others.

In conclusion Lawrence and Scanlon (2007: 523) reflect on the lack of development in project management in the past 50 years. ‘Modern, complex and globally distributed projects have outgrown the analytical and representational capabilities of these (planning) techniques’. They continue ‘Good planning means accurate scheduling and workload assessments, without these projects are dead in the water’.

Continuing Matta and Ashkenas (2003) also state good projects fail at an astonishing rate and that the focus is often not on the end result but on how the project is executed. Contrary to Lawrence and Scanlon (2007) Matta and Ashkenas (2003: 110) state that ‘managers expect they can plan for all the variables in a complex project in advance, but they can’t. Nobody is that smart or has a clear crystal ball’.

Matta and Ashkenas (2003) are supporters of the ‘rapid results’ approach, identify a portion of the project that can bring early results and ensure the project is results orientated. Matta and Ashkenas (2003: 112) state, ‘in most complex projects the executives shaping and assigning major work streams assume the vast majority of the responsibility for the project success. They delegate execution risk to the project teams, which are responsible for staying on time and on budget, but they inadvertently leave themselves carrying the full burden of white space and integration risk.’ In the arena of World Bank projects and strategically critical projects these risks can be immense.

The article stresses the need to be ‘results orientated’ and to identify items in the program that can yield early rapid results. The identification of these items can be of significant benefit in
generating milestone and identifying other weaknesses in the systems and in the project that can be addressed early on, without waiting for the end of the project introducing project delays and increases in costs. This is particularly relevant to the long duration large multidiscipline mining project.

Flyvbjerg, Garbuio and Lovallo (2009: 171) discuss huge spend in infrastructure development worldwide, this was then estimated to be in the region of 22 trillion dollars worldwide. The authors state that there is a poor record in the effective delivery of these projects. Continuing Flyvbjerg et al (2009: 171) state that, ‘Large infrastructure projects almost invariably arrive late, over-budget, and fail to perform up to expectations. Cost overruns and benefit shortfalls of 50 percent are common; cost overruns above 100 percent are not uncommon. For example, in one study of major projects in 20 countries, nine out of ten projects had cost overruns’.

As numerous as the projects are that overrun time and cost expectation are the reasons given for the cost and time overrun. According to the authors the reasons for the cost and time overruns are aspects such as; project complexity, technology and demand uncertainty, lack of scope clarity, unexpected geological structures, and opposing stakeholder points of view.

As with Lawrence and Scanlon (2007) Flyvbjerg et al (2009: 172) identify the project planner as the source of many of the errors that come in to the planning of the project. They identify three main categories of errors, ‘delusions or honest mistakes; deceptions or strategic manipulation of information or processes; or bad luck.’ They state that there is more or less universally an appreciation of the following sources of error: ‘risk of scope change, high complexity and unexpected geological features.’ As discussed elsewhere, according to the authors there tends to be a need to be optimistic towards the success of the project and to this end the costs are underestimated and benefits are overestimated and costs are hidden away. Harsh peer reviews of projects are therefore required to ensure the project costs, schedules and benefits have been properly accounted for and presented.

Flyvbjerg et al (2009: 173) consider deception as the second explanation for project failure, ‘decision making is flawed by strategic misrepresentation or the presence of what economists refer to as principal-agent problems’. Stakeholders ‘strategically overestimate benefits and underestimate costs in order to increase the likelihood that their projects, and not their competition’s, gain approval and funding.’

Mining project teams require projects to manage and there could be subliminal motivators to minimise risks to the project, overstate the returns and underestimate the costs.

Flyvbjerg et al (2009: 173) continue stating, ‘there are two cognitive delusions the inside view facilitates: the planning fallacy and a heuristic rule-of-thumb called anchoring and adjustment.’ Examining the anchoring and adjustment Flyvbjerg et al (2009) say the first number as a value for an operation is often inaccurate but given the value of the anchor value. On this value the thread
of inaccurate adjustments take place. All adjustments subsequent to this are often insufficient to correct the value realistically.

As with Lawrence and Scanlon (2007) Flyvbjerg et al (2009: 175) reflect on the planning for the large infrastructural project, ‘there is always a plan, which is very likely to serve as an anchor. Furthermore, the plan that is developed is almost always seen as a “realistic” best or most likely case. Executives know that events may develop beyond the best or most likely case so they generally attempt to capture unforeseen costs by building in a contingency fund that is proportional to the size of the project. However, when compared with actual cost overruns, such adjustments are clearly and significantly inadequate. Furthermore, the initial estimate serves as an anchor for later-stage estimates, which never sufficiently adjust to the reality of the project’s performance.’

Perkins (2005) identified two root causes for project failure; either the project managers not having the skills required or not applying the skills that they have. From Perkins (2005) the first cause results in project managers not knowing what is the easiest aspect to correct, this can be corrected by training. The second aspect according to Perkins (2006) is the less easiest to correct but can be adjusted by subordinate comments, and peer reviews.

According to Perkins (2005: 8) ‘Stories abound of project teams tasked to accomplish the impossible based on imposed constraints (e.g., cost, resources, performance, etc.). For example, the project manager may determine that a project will take 36 months to complete, but downward direction is to provide rubber on the ramp in 30 months. The only way to accomplish this is to take shortcuts’. From Perkins (2005: 8) the short cuts include eliminating peer reviews, configuration management, and risk management. This can be the root cause of expensive rework.

The expectations of the project must be reasonable and fairly achievable so as to remove the pressure to take these short cuts. This information would be available from the EPCM Company body of knowledge.

Expanding this Perkins (2005: 8) continues some mandated project management practices may be seen to be of little value in particular the planning processes required to be adopted, and peer reviews of documents and drawings. Perkins (2005) may have taken a somewhat simplistic view of project failure mechanisms placing the full responsibility on the project manager. Other project environment aspects and technical constraints may have a significant role to play in the project failure.

For a different perspective Brock, McManus and Hale (2009: 140) examine the military approach to reviewing project failures and concerns in a process described as being the AAR (after action review). ‘Reflection Today Prevents Failures Tomorrow’. In the view of Brock et al (2009: 140) company process improvement efforts can only be successful if improvement ideas are generated and proposed. There is a reliance on ad hoc task teams to develop process improvement proposals (PIP) that may be maintained in a database for periodic review. The military’s AAR
method, as a model for identifying process performer-generated PIP, may then be integrated into an organisational-level effort. PIPs are identified through lessons learned meetings, by phases, or at the end of a project. In contrast, Army AARs are an integral part of mission planning.

Brock et al (2009: 140) discuss the application of the AAR process within the project environment; ‘AAR is a professional discussion of an event, focused on performance standards, that enable soldiers to discover for themselves what happened and why it happened, and how to sustain strengths and improve on weaknesses. It is a tool that leaders and units can use to get maximum benefit from every mission or task. It does recognise success or failure but weaknesses to improve or strengths to sustain.’

Hayden (2006: 5) mentions the following non-technical project failure indicators:

<table>
<thead>
<tr>
<th>Failure Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>No designer oversee of the construction work onsite,</td>
</tr>
<tr>
<td>No access to the client for the engineer,</td>
</tr>
<tr>
<td>Designer not promptly and professionally responding to a design concern,</td>
</tr>
<tr>
<td>Design assumptions not being documented and translated to the client,</td>
</tr>
<tr>
<td>Design firm not managing project quality assurance tasks,</td>
</tr>
<tr>
<td>Design team perception that fees are not adequate to do the work,</td>
</tr>
<tr>
<td>Design technology requiring the advanced training of a client’s staff,</td>
</tr>
<tr>
<td>Key members of the team not working together before,</td>
</tr>
<tr>
<td>Designer yielding to client’s direction, resulting in operational difficulties.</td>
</tr>
</tbody>
</table>

To build on this list of conflict sources Hayden (2006: 6) cites suggests that internal to the organisation of the owner/client, the designer, and the contractor, there was a lack of willingness, ability, or both to anticipate and manage project conflict. The failure indicators were therefor based on human relationships. The site phase indicators included the lack of involvement of the designer and the contractors inexperienced supervision. Hayden (2006: 8) continues discussing the client satisfaction metric, the design company expects the client to participate in the design process and to fund changes in scope. The client expects the design company to understand the needs of the client business and to anticipate problems. The client also expects the project to stay in budget.

This is transferrable to the EPCM environment. Hayden (2006) obviously anticipates a dichotomy of goals and needs between the design engineering firm and the client, these aspects are seldom discuss at the project outset.

Hayden (2006) states that too often work is secured prior to understanding the full requirements and the work is secured hoping that the fees can be adjusted upwards as the work progresses. The author states, ‘until the client has expressed her/ his expectations to the project manager, the likelihood of project success is lowered. A productive relationship involves working through such
matters by addressing any conflicting expectations of the client and the design professional at the earliest possible time’.

To summarise Hayden (2006: 9) gives the following aspects:

- The educational programs do not prepare the engineer to appreciate and engage the human systems within and external to the project teams.
- Continuing to treat such conflict as a “special” cause when they are in fact “common” causes will continue to raise the cost of providing critical infrastructure with no increase in value-added.
- Project teams need to collaborate for project success.
- It is necessary to separate people from the problems. It moves the emphasis towards shared interests rather than individual positions.
- A key to the successful resolution of conflict appears to be the early identification of the conflict’s likelihood, its perceived importance, and the presence of a visible conflict process model.
- The professional’s lower interpersonal communication skill level, when combined with a lower-than-desired level of trust in the management of an organisation, can be the prime root cause of unacceptable project results.
- The prevention side of the cost of quality is far more beneficial than the “fix-it stage.” And yet, the bulk of the cost of quality dollars goes to corrective “fix-it” measures.

Hayden (2006) agrees with Millet (1999) with some of the principle causes of project failure as being:

- Recommendations not followed by client or contractor,
- Lack of disclosure (or understanding by client) of risks, uncertainties, and consequences,
- Technical errors or omissions,
- Accepting limited scope of work,
- Inadequate documentation,
- Lack of staff training,
- Breakdown of communication between senior management of all parties, technical staff, client, and contractor.

For Toader, Brad, Adamov, Marin, and Moisa (2010: 449) ‘in present times any kind of activity is considered as a project, which has a complex characteristic and which involves a new vision starting with the analysis of the project needs and finishing with the efficient re-usage of the project results’.
Though writing from an veterinary science view point Toader et al (2010: 449) have captured the challenges of the industry ‘The first one who offers what the client wants is the winner and has all the chances to survive in a competitive system’. Their solution is to use an efficient project management system. Toader et al (2010: 450) continue by stating ‘From project management point of view the success means the realisation of the planned objectives, the delivery of results according to deadlines and budget and its functionality should fit to the mission, objectives and purpose of the organisation’. Failure is when these objectives are not met, thus not meeting the clients expectations.

Toader et al (2010) arrived at the following list of project failure contributors:

- The objectives of the company are unknown at the lower levels,
- The plans propose too much in too short period of time,
- The financial estimations are not adequate,
- The plans were based on insufficient data and not approached systematically,
- The planning was not approached systematically,
- The necessary personnel are not available,
- The key points, including what should be reported are not known,
- The estimations are more or less guessed, they are not based on previous experience or on empirical standards and insufficient time allowed,
- The availability of the personnel who has the required knowledge and competence was not checked, and there is a high fluctuation of the project personnel with poor team retention,
- Not all the persons work with the same specifications,
- There is no consistency in the work, the deadlines are not taken into account,
- The project manager did not actively and efficiently participate in the project planning, to the responsibility distribution,
- The project manager is too ambitious.

Toader et al (2010) have not added too much that could be considered new to the discussion but have contributed a list of the principle drivers of project failure.

Reviewing Avots (1969: 77), he identified in the context of the 1960’s why some companies employed the project management philosophy; ‘Project management often seems the best approach to tasks which are not effectively handled through traditional methods. In the typical organisation, work is carried out by functional departments, such as engineering and manufacturing, and is supported by staff groups, such as personnel and accounting. In project management, on the other hand, a selected individual is given full responsibility for all aspects of
a distinctly defined element of the company’s business. While in some cases he may be assigned the required functional support, more often he negotiates directly for such support. Although many people view the project manager as a miniature general manager, he usually lacks the commensurate authority and depends on various management techniques to carry out his job’. From Avots (1969), the practice of project management was still in its infancy and was not in widespread application.

Avots (1969: 78) discusses the symptoms of project management failure ‘The symptoms of project management failure are many. Some of the more obvious indications are high costs or schedule overruns, poor-quality products, or, as in the case of ‘Sophisticated Systems’, failure to meet project objectives. A project that appears successful to the outside world may be a failure as far as the company is concerned because of the internal strife caused by redefinitions of the project's scope, large-scale design changes, and the need for additional funding’.

Avots (1969) gives the causes of project failure; the basis for project was not sound, selecting the wrong man as project manager, the company management was unsupportive, the tasks are inadequately defined, project management techniques were misused, and the project termination and close out is not planned. Further Avots (1969: 81) discusses the remedial actions and preventive measures to address the above concerns:

- Ensure the project planning is complete and the resources are available and dedicated,
- Ensure the project manager is qualified and experience in managing projects,
- Ensure the project is clearly defined and the operational structures are in place,
- Ensure the work packages are correctly sized,
- Use network planning techniques,
- Set up the supportive communication structures – formal and informal,
- Where the projects are long duration and have uncertainty – be prepared for re-planning and project dynamism,
- Provide for performance and reward,
- Plan for the closure of the project and the redeployment of the project team,
- Ensure there is a lessons learnt process in place to record the project successes and failures.

McCormick (2006: 102) is concerned with projects where formal project management methodologies are applied in a strategic context. ‘The underlying issue is that the application of what is apparently a comprehensive methodology does not appear to have much impact on rates of failure’. Continuing this argument McCormick (2006) debates that more time should be allocated to the interpretation of the project management methodologies and the integration of the project into the host organisation.
This is particularly relevant to the large multidiscipline mining project where the project is run by a client owners' team with little or no integration into the operational facilities of the client. This can result in a gap between what is expected and what is to be delivered at the completion of the project. McCormick (2006: 103) states ‘There is no doubt that the complete lifecycle of a project is covered in comprehensive detail, and it has built-in flexibility to adapt to local conditions’.

There is certainly a preoccupation with the application of methodologies and proprietary software to develop Gantt charts backed up with stakeholder analysis, risk analyses and lists of deliverables.

McCormick (2006: 103) states, ‘Frequently cited causes of failure focus on loss of control as expressed by financial overruns, time delays, changing specifications and loss of resources. The methodology thus tends to create a false sense of security in planning and control and a high potential for ‘surprises’”. McCormick (2006) is asking if we are being overtaken by the tools and procedures of project management?

McCormick (2006) states as above ‘Project success or failure is not therefore necessarily tightly linked to the methodology; it lies in the connection between the project and the organisation’, this would be at all stages of the development of the project. McCormick (2006) continues referring to the structure stating, ‘This structure makes connections between operational and project roles and attempts to address important issues such as position and authority in the organisation relative to the project. It does not, however, adequately reflect the scope and potential dynamics involved nor fully provide integration with the organisation’. Key to preventing project failure is to ensure the project is fundamentally linked at an operation level to the organisation. The project is the demonstration of the organisation either as a new development, an expansion or an operational change.

In conclusion McCormick (2006) states, ‘a project can be successful in terms of delivering the agreed specification, but this does not mean the specification itself is what was ultimately required by the organisation. Conversely a project may fail to deliver the agreed specification, but it may still deliver value to the organisation’. A successful project delivers value to the client and calls for good judgment, not just adherence to a process.

Taylor and Ford (2006: 51) discussing tipping point failures state that the ‘tipping point’ feedback structures can push product development projects into an introspective mode in which rework swamps progress. Similar mechanisms can also threaten the performance of mining projects. Taylor and Ford (2006: 52) offer the following definition of project failure ‘research has identified many factors that can lead to project failure; including overestimation of benefits, poor stakeholder analysis, and errors’. Identifying project failure is difficult not simply comparing differences between project performance and targets ‘variations of final project performance from targets can be poor measures if targets are flexible’.
Taylor and Ford (2006: 54) state that ‘project progress can slow, stop, and even turn negative for no apparent reason. The behaviour modes of increasing and then decreasing percent of work complete and increasing project backlog may be characteristic of projects that add many new tasks in a tipping point structure’.

Clearly the concern of Taylor and Ford (2006) is the growing burden of rework and new work, changes of scope being introduced into the program delaying the completion and the progress towards that completion. The project gets ‘snowed under’ with rework and additional work leading to an eventual project failure. This scenario can be prevalent in large multidiscipline mining projects.

Developing this theory Taylor and Ford (2008: 421) state tipping points are conditions that when crossed cause radical changes in behaviours and performance. According to Taylor and Ford (2008: 421) tipping points have been the cause of failures in large power station build projects and therefore could be the precursor of failure in large multidiscipline mining projects.

Taylor and Ford (2008: 421) state that ‘project management research has identified many factors that can lead to project failure including overestimation of benefits errors, lack of knowledge transfer between projects, rework, concealing rework, schedule pressure, and project complexity’. The large multidiscipline mining project can be subject to these factors and could therefore be subject to tipping point failures.

Taylor and Ford (2008: 421) state, ‘These projects are composed of multiple interrelated systems where changes in one system can also require unforeseen changes in connected systems, causal feedback between these systems cause projects to evolve over time in ways that greatly increase project complexity and make them difficult to manage.’ According to Taylor and Ford (2008: 422) there are several failure elements that are known to interact such as rework, schedule pressure and project complexity. These elements can lead to project failure.

Feedback loops have to be in control. According to Taylor and Ford (2008) when the feedback loops are not completing work but adding work the tipping point has been reached and the project that was previously in control becomes a project is out of control. The project personnel become ‘fire fighters’. The standard techniques for addressing the ‘out of control’ project include adding resources, pushing through lower standard work, crashing programs and reallocating resources.

The controlling processes are the processes that lead to the tipping point that leads to the project failure. Figure 2.2 below gives a graphical representation of tipping point dynamics in a project.
Figure 2.2 - Work flows through a project with a tipping point structure: from Taylor and Ford (2008: 423)

It can be seen above that there is a flow of work from one backlog loop to another. When the backlogs start to swamp the project, a tipping point has been reached and the project completion starts to tail off as seen in the figure 2.3 below. With aspects of the control being swamped there is an increased risk of defective items being passed on with the inherent risks.

Figure 2.3 - Typical model behaviour: from Taylor and Ford (2008: 424)

This would appear to be exaggerated for a large multidiscipline mining project, though project progress would be subdued.

Taylor and Ford (2008: 426) discuss the items required to alleviate the pressure on the project and avoid the tipping points. Taylor and Ford (2008: 427) state, ‘literature suggests many construction management policies to improve the likelihood of project success that can be modelled using the four model parameters tested. For example, the rework fraction can be
reduced through improved project learning, the ripple (interdependence of project work packages) effect strength can be reduced through project planning efforts focused on decoupling ripple effects, and schedule pressure can be reduced by setting realistic project deadlines.’

Clearly an understanding of tipping points can enable the project team to anticipate the arrival of tipping points and take the necessary pre-emptive actions. When a tipping point has been reached it can be analysed and corrective action taken to alleviate the tipping point.

Taylor and Ford (2008: 428) finish by saying that understanding and addressing tipping point dynamics can improve the management of large, complex construction projects. Thus by definition the understanding of tipping point dynamics can improve the management of large multidiscipline mining projects.

There is much to be learned from project failures, one of the key mitigating factors is understanding the project objectives followed by detailed planning and scheduling of the activities to be performed. The project objectives must be achievable and the carefully selected project manager needs to apply the necessary skills to the project execution and to managing the project risks effectively. The project measurements need to be understood and when adverse trends are noted then action must be taken to bring the project back on program, specification and budget.

### 2.11 Project success

Following on from the previous section the following section examines the actions required to give better assurance of project success. Project success for the large multidisciplinary mining project client would be achieving the required business objectives on time and on budget.

The establishment of criteria for and the measurement of project success is essential; highlighting areas of concern so they can be addressed, identifying and analysing good performances so they can be repeated, and for team motivation and reward. In order to measure the success of a project it is necessary to establish the performance measurement criteria for project success.

According to Hyvärri (2006: 31) project management literature it is still unclear what makes a successful project, the concept of project success has not been well-defined anywhere in project management literature. Hyvärri (2006: 31) also noted ‘that decades of individual and collective efforts by project management researchers since the 1960s have not led to the discovery of a definitive set of factors leading to project success’.

It could be deduced that there is no singular project success, and that all projects would have failed in one or more aspect. Equally importantly it could also be that the client or owner’s definition of success could be different to the EPCM Company’s definition of success.
Hyväri (2006: 31) continues saying that are many examples of projects exceeding their budgets, running late, or failing to meet other objectives. Though there are many project tools to aid project tracking there are none for human aspects of project management.

This could by itself indicate the need for additional or different project management performance criteria. The definition of success factors for the client or owner and the success factors for the EPCM Company that does not materially benefit from the completion of the project.

Hyväri (2006: 31) says that ‘future research concentrating on the relationship between critical success factors and measurement techniques and human elements in project management can be expected’. Hyväri (2006: 39) in his conclusion states the following, 'overall, the findings of this study suggest the need for further research in studying the role of effective communication in project management'.

From Zwikael and Globerson (2005: 3433), after many studies into the causes of project failure, most project managers can list the main factors that distinguish between project failure and project success these are usually called Critical Success Factors (CSF). Despite this the number of project failures remains high. Often, according to Zwikael and Globerson (2005: 3434) the CSF are vague and fail to contain the details of what is expected. Without clear guidelines as to what is required the project manager will have difficulty in implementing and will lack the guidelines for decision making.

Zwikael and Globerson (2005: 3439) provided the following list of planning processes:

<table>
<thead>
<tr>
<th>Project plan development</th>
<th>Resource planning</th>
<th>Scope planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost estimate</td>
<td>Scope definition</td>
<td>Cost budgeting</td>
</tr>
<tr>
<td>Activity definition</td>
<td>Quality planning</td>
<td>Activity sequencing</td>
</tr>
<tr>
<td>Organisational planning</td>
<td>Activity duration estimate</td>
<td>Staff acquisition</td>
</tr>
<tr>
<td>Schedule development</td>
<td>Communications planning</td>
<td>Procurement planning</td>
</tr>
</tbody>
</table>

And the familiar project success factors:

<table>
<thead>
<tr>
<th>Schedule performance</th>
<th>Technical performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost control</td>
<td>Customer satisfaction</td>
</tr>
</tbody>
</table>

Using these factors Zwikael and Globerson (2005: 3439), in table 2.6, derived a ranking for the planning process from a detailed survey, the following results were obtained:
Table 2.6 – Ranking of the planning processes and extent of use: derived from Zwikael and Globerson (2005),

<table>
<thead>
<tr>
<th>Activity duration estimating</th>
<th>Customer satisfaction</th>
<th>Technical performance</th>
<th>Schedule overrun</th>
<th>Cost overrun</th>
<th>Extent of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope planning</td>
<td>14</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>4.1 – 2</td>
</tr>
<tr>
<td>Activity Definition</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4.1 – 2</td>
</tr>
<tr>
<td>Project plan development</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>4.0 – 4</td>
</tr>
<tr>
<td>Schedule Development</td>
<td>3</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>4.0 – 4</td>
</tr>
<tr>
<td>Resource planning</td>
<td>15</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>3.9 – 6</td>
</tr>
<tr>
<td>Organisational planning</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>3.8 – 7</td>
</tr>
<tr>
<td>Scope definition</td>
<td>13</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td>3.6 – 8</td>
</tr>
<tr>
<td>Staff Acquisition</td>
<td>6</td>
<td>2</td>
<td>11</td>
<td>14</td>
<td>3.6 – 8</td>
</tr>
<tr>
<td>Activity sequencing</td>
<td>10</td>
<td>14</td>
<td>10</td>
<td>8</td>
<td>3.4 – 10</td>
</tr>
<tr>
<td>Cost budgeting</td>
<td>9</td>
<td>9</td>
<td>4</td>
<td>5</td>
<td>3.2 – 11</td>
</tr>
<tr>
<td>Procurement planning</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>4</td>
<td>3.0 – 12</td>
</tr>
<tr>
<td>Cost estimating</td>
<td>11</td>
<td>10</td>
<td>13</td>
<td>15</td>
<td>3.0 – 12</td>
</tr>
<tr>
<td>Quality planning</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>2.9 – 14</td>
</tr>
<tr>
<td>Risk management planning</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>11</td>
<td>2.7 – 15</td>
</tr>
<tr>
<td>Communications planning</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>10</td>
<td>2.3 – 16</td>
</tr>
</tbody>
</table>

Reviewing the above there is an obvious tendency for project managers to focus on the easier aspects of planning and to avoid those aspects where there are 'less clear' guidelines. Processes that were identified by Zwikael and Globerson (2005) as critical for the engineering industry and by inference the mining industry were; activity definition, schedule development, project plan development, cost budgeting, activity sequencing, scope management and cost estimating.

In the measurement of project success Bryde (2005: 119) discussed the new environment for the development of performance measuring systems, according to Bryde (2005) management literature reports changes in the theoretical structures of performance measurement over the last 20 years. Frustration with ‘traditional’ performance measurement systems (PMS) led to the development of ‘balanced’ or ‘multi-dimensional’ frameworks and PMS models, such as the well-known Balanced Scorecard (BSC) model. The new PMS were seen to address the limitations of the old ‘traditional’ PMS. For example the newly emerging PMS helped the achievement of continuous improvement goals and guarded against the dangers of complacency. However, the development of new PMS models introduced a level of complexity. Measuring performance
requires understanding of a balance of different perspectives from different stakeholder groups. But it is recognised in the literature on the subject of organisational effectiveness that different stakeholders use different criteria/ key performance indicators (KPIs) to assess effectiveness and that it is rare that organisations fulfil the KPIs of all groups simultaneously. Therefore, the need for balance is accompanied by ensuing complexity.

Returning to the aspect of project success Chan, Chan, Chiang, Tang, Chan and Ho (2004: 188) state that the construction industry is beset with several problems, such as; lack of cooperation, limited trust, and ineffective communications. This can lead, as we have seen to an adversarial relationship among all the stakeholders. This leads to delays, difficulty in resolving claims, cost overruns, litigation, and a win-lose relationship.

Chan et al (2004: 190) give the following list of points as being significant in project partnering success:

- Provide adequate resources,
- Support from top management,
- Mutual trust between partners,
- Long term commitment,
- Effective communication,
- Efficient coordination,
- Productive conflict resolution.

On a more positive and practical note Brown and Singh (2014) offers recommendations for engineers to reduce capital cost and operating costs, reduce schedules and improve engineering design and contributing to project success.

Brown and Singh (2014: 51) state that you can do more with less by following these criteria:

- The project team, before work begins, sets clear, measurable objectives using input from both business and technical managers,
- The project team creates and studies a comprehensive list of design options early on, and continues doing so throughout the life of the project,
- The project team develops a project schedule and plan at the start of the project, based upon firm decisions made early in the project,
- Management staffs the project with an appropriate number of experienced engineers from the key disciplines.

Brown and Singh (2014) reviewed the focus on options in the creating of the options list. The decision makers need to increase the scope and increase the number of options considered, carry out reality checks on the options, conduct self-peer reviews on the options and carry out risks
assessments on decisions. Following this process according to the authors will result in the selection of the most appropriate options for the project.

Brown and Singh (2014) discuss the application of 3D modelling software as a means for creating awareness in the team of the complete scope of the project. The 3D modelling packages available to the project teams have the capabilities of; integrating knowledge data bases, integrated calculation routines, automated bill of quantities, and layout option development. 3D modelling has become very popular for many aspects of the large multidiscipline mining project. These and other aspects enable the project team to construct a virtual plant and develop a team focus on the completed item in the critical design phase of the project.

Rolstadås, Tommelein, Schiefloe and Ballard (2014) attempt to prove a link between project success and the project management approach selected. They define two different approaches in project management:

- The prescriptive approach that focusses on the formal qualities of the project organisation, including governing documentation and procedures.
- The adaptive approach that focusses on the process of developing and improving a project organisation, project culture and team commitment.

Rolstadås et al (2014) table the following paradox - a project can be successful even though the project was not managed successfully. The opposite can also apply in so far as the project can be successfully managed but the completed project fails to meet the objectives of the client.

Rolstadås et al (2014: 641) following from Chan et al (2004) lay out the following familiar factors critical for project success:

<table>
<thead>
<tr>
<th>Support from senior management</th>
<th>Skilled/ suitably qualified/sufficient staff/ team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear realistic objectives</td>
<td>Effective change management</td>
</tr>
<tr>
<td>Strong/ detailed plan kept up to date</td>
<td>Competent project manager</td>
</tr>
<tr>
<td>Good communication/feedback</td>
<td>Strong business case/ sound basis for project</td>
</tr>
<tr>
<td>User/ client involvement</td>
<td>Sufficient/ well allocated resources</td>
</tr>
</tbody>
</table>

Regarding specific projects Rolstadås et al (2014: 649) describe the success factors from a Norwegian Oil and Gas project:

- Aligned governance: a common governance structure with all involved partners in the project was agreed at the very beginning.
- Recruitment strategy: managers selected participants on the basis of their known competence as well as their former relations and personal networks.
• Established ways of working: the organisation had a general acceptance of an established way of working.

• Project tools: well-proven project management tools with specifications, deliveries, and schedules were used according to well-established practice of the operating company.

• Contract strategy: a flexible contract strategy tailored to maximise the benefits from a competitive market was adopted. Each of the main contracts was followed up by a company representative.

• Risk management: an extensive system for risk management was established.

• Existing relations: existing working relationships across organisations laid the foundation for developing a project culture characterised by openness.

• Information strategy: an important mechanism for obtaining good coordination was to hold regular meetings, both within the management group and within sub-projects.

• Stakeholder management: a clear strategy for managing all external stakeholders was developed and implemented.

Following on from the above Rolstadås et al (2014: 653) identified the success factors for an infrastructure project in the United Kingdom thus:

• Application of a systems integration model; this involved six processes for a megaproject.
  o Systems integration to coordinate the design, engineering, integration, and delivery of a fully functioning operational system,
  o Project and program management to support an integrated supply chain,
  o Digital design technologies to support design, construction, integration, and maintenance activities,
  o Off-site fabrication, pre-assembly, and modular production, to improve productivity, predictability, and health and safety,
  o Just-in-time logistics to coordinate the supply of materials, to increase speed and efficiency,
  o Operational integration to undertake systems tests, trials, and preparation for hand-over to operations.

• Continuous project process improvement; a standard set of guidelines was introduced as a project handbook. The intention was to improve the project development and project management process by ensuring a consistent approach which meets business needs and opportunities and thus created continuous improvement across the organisation.

• Team working environment; this helped build trust throughout the project organisation.
• Project branding: a strong focus on the project brand followed up by personnel training created strong commitment toward the project objectives.

Rolstadås et al (2014) summarised that there is no single solution for project success, success will depend on the project dynamics and the stakeholder dynamics. Dependent on the project management approach the success factors will change. They state that the project management approach should be determined at the outset of the project.

The design decision for the project and project organisation is a critical decision for all large multidiscipline mining projects.

According to Sato and de Freitas Chagas (2014) the ‘normal project life cycle does not account for the long-term effects of the megaproject which can have an impact on the perception of success’. ‘Thus the megaproject life cycle should include a significant part of the operational life cycle of the end product or result, and the criteria of success should include the long-term benefits of the project’. This concept could have significance when reviewing the long project lifecycle of the large multidiscipline mining project. For Sato and de Freitas Chagas (2014: 625) the usual definition of the success of the project in time, cost and quality are not enough for projects with a higher degree of complexity such as megaprojects.

Sato and de Freitas Chagas (2014: 625) propose a ‘redefinition of the concept of project lead time to encompass the time between the project initial idea, when a value creation proposal is considered, and the moment when success is being assessed by the stakeholder, using any criteria they are considering as value metric at such specific moment. Value depends on the utility and utility depends on the specific circumstances of stakeholders. Also the criteria for a megaprojects’ success should include longer term aspects of the project outcome, such as its legacy, which might mature in very particular pace’.

According to Sato and de Freitas Chagas (2014: 629) in an attempt to integrate the notion of project success for large-scale projects five dimensions of success criteria were proposed; efficiency, impact on customer, impact on team, business and direct success and preparation for the future:

• Efficiency refers to the usual triple constraint,
• Impact on customer refers to the usual customer satisfaction/ acceptance,
• Impact on team recognises the importance of people in projects, and that the internal team satisfaction can be valued at the same level as the external customer satisfaction,
• Business and direct success,
• The preparations for the future criteria are concerned with the wider organisation sponsoring the project, and its long-term viability.
Issue of time (when success is assessed) is important, as it is important the level of the stakeholder and the kind of metric considered in value creation. For example, megapar

[469x49]ojects can have impact at the level of government and country, so the impact on value creation considered by society is assessed in several years or decades after the project is completed.

In conclusion Sato and de Freitas Chagas (2014: 633) focussed on assessing success for megaprojects ‘we have argued herein that the utility theory should be considered as an important element in the redefinition of project lead time. The authors suggest that the success of the megaproject should be evaluated after the formal close of the project. Project that would be deemed to be a failure in normal project terms could be deemed successful should the viability of the project be determined after the completion of the project.


| Examine and prioritise your motives and strategic objectives, and is a win-win relationship likely for you and your partner? |
| Select partner organisations that have compatible or complementary competencies, management practices, and organisational cultures. |
| Be clear on and agree with partners on operational goals and performance targets. |
| Be realistic in setting objectives and performance targets. |
| Have clear and unambiguous governance mechanisms and definitions of the roles and responsibilities of the partner organisations and the middle and senior project managers. |
| Consult and build consensus. Seek out the views of local partners and stakeholders in the community and try to integrate the best of the management traditions of the host country as much as is possible, consistent with corporate and project goals. |
| Ensure the commitment of senior management at headquarters by having a project champion and providing services to ease the life of expatriates. |
| Constantly assess the socio-political and economic environment of the project, weighing its feasibility in the first place, making ongoing adjustments during implementation, and having programs to consult with and influence local and international stakeholders and build community support. |
| Recognise the importance culture will have on project management, and select and train personnel to be culturally sensitive and effective collaborators with people of another culture. |
| Trust your partners until proven wrong. |

There are factors that define the success of a project and a set of factors that improve the opportunities for success in the project. From the literature there was a lack of consensus on what would define a successful project; from the client point of view this would be a project completed on time, on budget and meeting the objectives of the project. In addition to this there are a set of
project management activities and behaviours that precipitate project success, critical amongst these are clarity in the project objectives, adequate funding and access to resources and a commitment from the client or end user.

2.12 Conflict management

In the execution of a large multidiscipline mining project the project manager will be required to bring together a group of personnel and from the client, major contractors and from the EPCM resource pool, the only common ground for these resources is the execution of the project, each group will have their own objectives. These objectives may not be fully aligned and thus there is inevitably going to be conflict and thus a requirement for conflict management. The articles that are discussed in this section examine conflict in the large project environment. Conflict is exacerbated by the execution of the project in the international environment.

This topic was discussed by Ng, Peña-Mora and Tamaki (2007) where they state that ‘one major critical characteristic of the construction industry is the high cost incurred by the resolution of arising conflicts in projects’, As a result of this project managers are obliged to avoid conflicts and if they do occur resolve them effectively and fairly.

The authors Ng et al (2007) further discuss that construction projects exist within an adversarial environment making conflict inevitable. Because of this project managers should actively focus on avoiding and preventing conflicts from escalating into claims and resolving claims to prevent them from becoming expensive disputes and lawsuits.

Conflicts may not be avoidable but they should be detected as soon as possible the consequences mitigated through effective mediation. In 2007 alone according to Ng et al (2007) disputes present in the construction industry in the US cost approximately $5 billion. Clearly the early and fair resolution of conflicts is an essential facet of project management, particularly in the adversarial construction industry.

Quoting Ng et al (2007: 53) describe the evolution of the conflict: ‘an adversarial attitude is reflected in antagonistic relationships, ‘win-lose’ attitudes and general dissension.’ There is tendency to postpone the resolution of disputes and to focus on the project activities until the project is complete. Unresolved problems that hold up payments create uncertainty as to the outcome and engender even more adversarial relationships, which cause further delays and disruptions. These delays and disruption adversely affect not only the project completion, they cause added costs to the project participants, which in turn gives rise new claims and disputes. Ng et al (2007: 55) propose the dispute resolution ladder summarised in the table 2.7 here:
Table 2.7 – Dispute resolution ladder: derived from Ng et al (2007: 55)

<table>
<thead>
<tr>
<th>Prevention</th>
<th>Prevention techniques focus on minimising the sources of potential conflict on a project. Good project management can thus go a long way towards the prevention of conflict on a construction project. Communication could be seen as being a primary conflict resolution technique.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negotiation</td>
<td>Negotiation is a process in which parties discuss their differences through meetings and open dialogue in an attempt to resolve their disagreements quickly. Negotiation is a process involving communication intended to result in an agreement, and commitment to a course of action. Effective meetings and thorough communication can thus be seen as an effective tool in the prevention of conflict during the execution of the project.</td>
</tr>
<tr>
<td>Standing neutral</td>
<td>A neutral third party is selected by party participants; the neutral third party is allowed to observe project activities and evaluate and resolve disagreements, when and if they arise. The knowledgeable professional aims to provide objective and unbiased feedback in a timely manner to prevent adversarial relationships from growing and hardening. Dispute review boards play a similar role as a standing neutral except they are in the form of a panel. When the situation requires it then a neutral third party can be drawn in to the process to act as an independent review and arbitrator.</td>
</tr>
<tr>
<td>Non-binding resolution</td>
<td>Non-binding dispute resolution procedures result in a mutually agreeable solution with the aid of a neutral facilitator, who assists in reaching a settlement. Parties can enter into proceedings voluntarily and select the third party by mutual consent; therefore, the facilitator’s role is advisory and non-binding.</td>
</tr>
<tr>
<td>Binding Resolution through Arbitration</td>
<td>Arbitration is the most popular form of binding dispute resolution. It is designed for quick, practical, and economical settlements.</td>
</tr>
<tr>
<td>Litigation</td>
<td>Litigation would be the final step in the dispute resolution ladder where one side will win and one side will lose.</td>
</tr>
</tbody>
</table>

With large multidiscipline mining projects there is a need to work in an international environment and call on resources from a global resource; this brings its unique challenges to the project. In addition to the challenges of global resourcing are the challenges of truly global project.

This is reflected on by Mahlingham and Levitt (2007) who studied the global construction projects that involve collaboration between participants from multiple countries, they discovered that this often results in challenges, and costs due to international interaction. Mahlingham and Levitt (2007) reviewed the classification of conflict, determined the causes and give an indication on how the conflict can be resolved.
The construction environment is showing increasing tendencies for globalisation and there is an increasing trend for global projects. According to Mahlingham and Levitt (2007), for any large engineering project, large global projects involve a great amount of technological and organisational complexity in addition to complex coordination requirements. Project complexities such as these often lead to confusion with project participants, delays, and increased costs.

Mahlingham and Levitt (2007) quantify this with an ‘analysis of several large engineering infrastructure projects in the energy, power, petrochemical, and nuclear sectors, the majority of which were global projects, indicated that these cost overruns frequently occurred and could range from 30 to 700% of estimated costs’. Globalisation is affecting many category of projects and as the capital cost of new ventures increases along with the need to identify new minable reserves so it affects the mining industry.

As stated by Mahlingham and Levitt (2007: 517), ‘In addition to the complexities present in most large engineering projects, global projects are distinct from other non-global large engineering projects in that global projects involve interactions among individuals, organisations, and agencies from diverse national backgrounds and cultural contexts’. Such interactions can lead to; technical misunderstandings, increased costs, project participant disagreements, project coordination and communication difficulties. In the project environment this will lead to significant additional costs and time overruns from the original project estimates.

The effects of globalisation on project cannot therefore be ignored and a program to address these risks has to be identified and implemented. Mahlingham and Levitt (2007) derived the following six sub-categories for the global project planning, design and construction phases:

- Problems due to different information gathering techniques,
- Delays due to conflicting aesthetic views,
- Problems due to differences in building codes,
- Problems due to differences in available building materials,
- Delays due to differences in contracting practices,
- Delays due to differences in regulations.

Specifically, in project planning Mahlingham and Levitt (2007) found that there were differences and regional constraints in the data collection process. In the design phase there were regional variations in the operating characteristics of the completed structures the end result was a period of conflict until the local norms could be adopted. On a technical level there was a considerable effort required to harmonise the relevant design codes and to ensure the designs were in compliance with the host country requirements.

Mahlingham and Levitt (2007) also identified the differences in locally available materials as being a source of conflict. Local design activities would tend to follow the premise that the chosen
materials would be regionally available. In the construction phase Mahlingham and Levitt (2007) identified two main sources of problems, the fundamental differences in the contracting practices and the regulations. In the construction phase the parties become exposed to the differences in the regional regulations and the required permitting. Mahlingham and Levitt (2007) describe some of the challenges in understanding the local regulations and secondly in completing all of the regional and local documentation in order to commence with the construction activities.

According to Mahlingham and Levitt (2007) there is no substitute to spending time to understand the local construction practices, there is little literature available to explain the local differences in the regulations and practices. Also from Mahlingham and Levitt (2007: 525), ‘Project participants often wish to persist with their own cultures and work practices as they are used to working with such practices in their own institutional environments’. ‘When neither side is willing to relent, conflicts result on which practice to follow’. ‘Reconciling these differences and determining how to act in the face of unfamiliar, “foreign” institutions may lead to misunderstandings, extra work to resolve them, and hence extra costs to a project in terms of time, money, or quality’.

The other source of conflict within a project is when, for reasons of expediency or cost it becomes necessary to draw in resources from other countries or to subcontract tranches of work to resources based in other countries. In addition to this there is growing pressure being placed on procurement (for example) to globalise the procurement for a project. A fabricated item would for example be procured from a foreign country without the relative protection of an original equipment manufacturer controlling the manufacturing process. Each of these scenarios can be the source of conflict within a project.

According to Hayden (2006: 2) ‘Conflict is a natural human reaction in the workplace’ and that the nature of the engineering project with the mix of skills, the lack of resources and the time constraints heightens the potential for conflict. This is aggravated by the fact that the people on the project would be aware that it is unlikely they will be required for work together again. With the EPCM environment however the persons working on the project would be working for the same company.

Regarding new engineers Hayden (2006: 2) comments that most new recruits to the engineering work place are often unprepared for the conflicts that they are about to face. Following on from this Hayden (2006) states that the introduction of a ‘human systems’ module into graduate training would go a long way to addressing project failures due to human social conflict. In effect the engineering graduates are well equipped to solve the technical issues but not the human interface issues in the workplace. According to Hayden the engineering training and direction avoids the human side of project skills.

Akiner (2014) discusses the management of conflict in multi-national construction projects. The construction industry is increasingly looking at the global resource market for the establishment of
construction team. Akiner (2014: 1038) discussed that conflict management is becoming ever more important and an essential skill for the project manager due to the changes in the construction industry, global influences, team cultural diversity and project execution complexity. Any of these aspects can drive the necessity for speedy and effective conflict resolution making this an essential skill for the effective project manager.

There are many sources of conflict during the execution of the large multidisciplinary mining project. Conflicts are caused by differences of opinion and require resolution before they impact on the project execution. With large multidiscipline mining projects being executed in the International arena there is a greater propensity for conflict during execution, this requires a greater effort in the planning phase and during project execution to ensure the reasons for conflict a mitigated during the planning phase of the project and during execution to prevent delays and costs during project execution.

2.13 Conclusion

In this chapter the framework of PMI PMBoK® 5th Edition and the 3rd Edition on the Construction Extension have been reviewed to establish a direction and structure for the development of recommendations.

The section headings for the literature review were established during the high level scan of the project management literature.

Literature relevant to the activities of the EPCM Company engaged on a large multidiscipline mining project has been reviewed in this section, this was to identify areas that can be developed and studied further to enhance the performance and success of the EPCM Company.

The following chapter, chapter 3 examines areas of project management in literature that are particularly relevant to the Client and the EPCM Company interaction with the client.

Chapter 3: Client aspects of project management

3.1 Introduction

In chapter 3 the literature relevant to the client’s project processes is reviewed and presented. The sections identified here are of relevance to the clients’ processes and the EPCM interface and interaction with the client.

The key aspects are developed in to a questionnaire and the level of understanding and application established in the host company.
3.2 Project management philosophy

Project management is fundamental to managing any activity and relies on the actions of people. Project management processes are more frequently being applied to many activities in business hence the growing interest in project management as a business management topic.

This section examines the topic of project management philosophy and the novel techniques being examined by academics. Three articles were identified that supported this topic in chapter three.

Whitty (2011) examined the prevalence of modern project management and reviews in particular the applicability of the PMI approach to project management. Whitty (2011) summarised that in his opinion project management is a cultural obligation along with the creation of project management artefacts. According to Whitty (2011) we hand these artefacts down to the next generation through a process of subliminal mentoring and an ancient survival instinct.

Whitty (2011) alludes to the principle that project management is far more than the mechanistic delivery of a technical solution for the benefit of a client and thus developed a new philosophy on project management. Whitty (2011: 525) examined the principles of natural selection as applied to the principle of project management, ‘My thesis applies evolutionary principles to various aspects of project management. That is to say that the practices and artefacts modern project managers find around them are there because they have survived a process of selection and replication for various reasons’. Further Whitty (2011: 526) reflects on the popularity and prevalence of project management as a field of study and the growth of project management practices in the working environment but paradoxically as he reflects projects continually run over their schedule and budget. Why then Whitty (2011) asks, is project management ‘more popular than ever when so many fail’.

Why is project management so prevalent if it appears to lack effectiveness? There would appear to be a need to re-examine the structure and application of project management principles.

Chen, Nunamaker, Briggs, Corbitt, Sager and Gardiner (2014) voice the opinion that because of high project expenditure it is important to understand the factors that affect team performance. For Chen et al (2014) it is important to understand project process management in so far as it creates visibility of the processes which would increase the likelihood of project success. According to Chen et al (2014) this would traditionally be a process of chatting informally to project team members but with the advent of virtual project teams this process can no longer work. This obviously bridges project systems, team and communication.

Chen et al (2014) discuss, the dissemination of information to create awareness and understanding of the project amongst the team members and the importance of this for project success, and the importance of project progress tracking. In support of this Chen et al (2014) raise the aspect of ‘collaborative engineering’ as a work processes for high value recurring tasks and transferring those tasks to practitioners to execute for themselves without the ongoing intervention
of professional engineers. The fundamental tool for this process is the group support system or GSS. According to Chen et al (2014) the GSS system can assure anonymity where this is beneficial, parallel input, group memory, and structured group interaction. The collaborations are managed through a dedicated collaboration engineer.

Chen et al (2014: 969) identified the three steps to collaborative engineering:

- identifying and defining a recurring collaborative task,
- identifying the best practice for the task,
- designing collaboration tools to support the task.

The GSS systems described by Chen et al (2014) could be seen as being one of the new trends in project management as resources become more and more scarce. In addition to this the financial constraints being experienced by many clients is causing EPCM Companies to examine ways to execute project more efficiently and cost effectively.

Magaba, Cowden and Karodia (2015) review the impact of information and communication technology, industry has been forced to investigate ways to improve the delivery of complex and demanding projects. They found that the dispersed nature of the organisations in the industry they were examining lead to poor communication and poor transfer of information. Continuing Magaba et al (2015) state that the construction industry had to become more efficient and innovative in the use information technology, and that due to the rapidly changing technology and the need to implement quickly has led many companies to implement technology that does not meet their requirements. The rush to implement information technology systems has resulted in the systems not being fully and effectively implemented. They cite the following reasons:

- New systems not interfacing with existing systems,
- No adequate training of the end-user,
- Some systems require a large number of people to administer them, which has not been budgeted for,
- Unwillingness from employees to change working methods and resistance to change,
- Inadequate technical support.

Magaba et al (2015) saw a gap between project management and the impact of technology and discussed the problems that can be created in the transfer of information from one part to another; there can be information overload, information can be withheld or delayed and information can be distorted or altered.

There is a need for efficient information transfer in project environment and there is a need for organisations to move away from using outdated business practices and adopt methods that will
help move the industry forward. It is clearly not enough to decide on implementing a system without reviewing the needs of the company.

In this section articles were reviewed that cite the need for a new approach to project management, project management is not solely the application of principles and practices, project management is more the effective management of the human resources. Recent studies have focussed on the communication aspect of project management and the effective use of communication systems and the implementation of collaborative engineering processes.

### 3.3 Last planner

To manage a project a project plan is required, the more detail that can be included in the project plan the greater the opportunity to successfully model the project and schedule the resources required for the execution of the project.

As discussed in chapter two detailed planning is seen as being fundamental to the success of a project. In a large multidiscipline mining project there is often insufficient information at the start of the project to empower the planner to produce a detailed project plan.

The ‘Last Planner’ is a specific project planning process that embraces the rolling planning process for managing large multidiscipline projects. The project scope definition is only clarified during the execution of the project thus effort expended during the early phases of the project is based solely on preliminary data.

Koskela and Howell (2002: 1) discuss the unique features of two project management methods which radically deviate from the conventional principles of project management: these methods are titled ‘Last Planner and Scrum’. The ‘Scrum’ applies to software projects and the ‘Last Planner’ to construction projects. They show these methods reject the underlying theoretical foundation of conventional project management and revert to alternative theories, which better match large multidiscipline projects. The tables 3.1 and 3.2 below show the development of the theory of project management as cited by Koskela and Howell (2002).

Table 3.1 - The underlying theory of project management: from Koskela and Howell (2002: 2)

<table>
<thead>
<tr>
<th>Subject of theory</th>
<th>Relevant theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Transformation</td>
</tr>
<tr>
<td>Management</td>
<td>Planning</td>
</tr>
<tr>
<td></td>
<td>Management-as-planning</td>
</tr>
<tr>
<td></td>
<td>Execution</td>
</tr>
<tr>
<td></td>
<td>Classical communication theory</td>
</tr>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>Thermostat model</td>
</tr>
</tbody>
</table>
Table 3.2 - Ingredients of a new theoretical foundation of project management: from Koskela and Howell (2002: 4)

<table>
<thead>
<tr>
<th>Subject of theory</th>
<th>Relevant new theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Transformation, Flow, Value generation</td>
</tr>
<tr>
<td>Management</td>
<td>Planning: Management-as-planning, Management-as-organising</td>
</tr>
<tr>
<td></td>
<td>Execution: Classical communication theory, Language/ action perspective</td>
</tr>
<tr>
<td>Control</td>
<td>Control: Thermostat model, Scientific experimentation model</td>
</tr>
</tbody>
</table>

As we are examining the large multidiscipline mining project practices the ‘Last Planner’ philosophy is reviewed.

From Koskela and Howell (2002: 5) ‘Last Planner’ appears to deviate from the conventional project management doctrine in terms of planning, execution and control. The process is described by Koskela and Howell (2002: 5) as a hierarchical chain of planners, where the last planner acts at the interface to execution, the last planner concentrates on the detailed planning just before execution, rather than the whole planning process.

The method of last planner distinguishes planned tasks according to Can, Should and Will modalities. The tasks pushed from the higher planning levels belong to the ‘Should’ category.

Koskela and Howell (2002) state that ‘In look-ahead planning (with a time horizon of 3–4 weeks), the prerequisites of upcoming assignments are actively made ready, and in other words, they are transferred to the “Can” category. According to Koskela and Howell (2002) only the “Should” category is recognised. In addition Koskela and Howell (2002) also espouse maintaining a buffer of tasks for each crew. Thus, if the assigned task turns out to be impossible to carry out, the crew can switch to another task thus avoiding lost time.

“Should” represents the tasks in the plan, and “Can” represents those tasks that realistically will be possible to start in the situation. Thus, look-ahead planning subscribes to the view of human action as situated, managing-as-organising, while also acknowledging the significance of plans for action - as advocated by managing-as-planning.

Koskela and Howell (2002: 5) expand the execution. A weekly dispatching procedure where only tasks in the “Can” category are transferred to the “Will” category. At the conclusion of the week there is feedback from the teams on the success of completing tasks. This procedure contrasts to the conventional project management, where execution just consists of task authorisation: the site manager notifies the subcontractor or the crew that the task should be started. Theoretically interpreting, the execution phase in ‘Last Planner’ is similar to the language/ action perspective.
model in that communication is a two-way process, and commitment is created for the realisation of the tasks within the planning conversation where plans prepared by one crew are understood as promises to others and through the obligation to report on the completion of the task.

Koskela and Howell (2002: 6) discuss the theory of control as being the measurement of the realisation rate of assignments, investigating the cause for non-completion and the mitigation of those causes. This is conventional thinking as is the measurement of the completion progress and rates. Koskela and Howell (2002: 6) in discussing theory of the project advocates the ‘Last Planner’ process as ‘conforming to the generic principles of flow management, avoiding both variability propagation and unnecessary penalties, and combining control and improvement reducing waste or project resources it.’

The ‘last planner’ theory seems particularly relevant to the execution of large multidisciplinary mining projects where there is an evolving scope definition during the execution of the project. The ‘last planner’ has the clarification of the scope and can thus add the detail to the project plan and schedule the resources to the project execution.

3.4 Agile project management

Following on from the last planner theory of project planning where there is an evolving project definition comes the application of more versatile project management practices. This is of particular relevance to the large multidiscipline mining project and is the aspect that gives flexibility and versatility, this is improvisational and agile project management.

Leybourne (2009) discussed ‘two aspects of the increasing body of research in the field of project management, namely improvisational working and agile project management’. Leybourne (2009) states that there has been a recent shift away from prescriptive project management to a more behavioural based and improvisational project management. This they note was being driven by the less predictable project environment. Leybourne (2009) indicates that the shift has also been shift to facilitate the necessity to take advantage of emerging opportunities.

As anticipated by Leybourne (2009) the large multidiscipline mining project, being of long duration and complex are required to change pace and direction when subject to changes in funding, industrial action, national infrastructure weaknesses, operational costs and commodity valuations.

There is according to Leybourne (2009) two distinct camps, one where process and control is required and an emerging new paradigm of agility to accommodate the uncertainty, turbulence and changing requirement. The new paradigm uses creativity, intuition and the team tacit knowledge. These two ‘camps’ obviously need to be explored further to gain a greater knowledge of the relative merits and application of each. From a review of the texts Leybourne (2009) identified the following key aspects:
• Improvisational project management: linked with aspects of time, and particularly pressure to achieve to a demanding or compressed timetable. Although projects are usually managed according to time, cost, and operational targets, it is the time-based aspect of project delivery that often has the highest scrutiny.

• Agile project management: (APM), requires adaptive employees, operating within organisations that are themselves able to adapt to changing environments and requirements.

To enlighten further Leybourne (2009: 524) states that ‘The fundamental principle of APM is a shift from the traditional and prescriptive “plan-then execute” project paradigm, which embraces the fundamentals of the four stage project life cycle, towards a new five phase model. The five phases within the APM model are envision, speculate, explore, adapt, and close, and the underlying ethos is that in attempting to meet the requirements of a given project, team members should explore different ways of arriving at the outcomes of a project, and test and adapt the more acceptable solutions on an on-going, iterative basis until the requirements are met.’

• Creativity: is supposedly harnessed to develop new and better ways of executing project work, although there is evidence to suggest that it is also applied in an unplanned way to resolve project challenges. ‘The delivery of benefits measured in terms of time, cost and quality is a challenge to project managers, and the application of creative thought may assist’.

Leybourne (2009: 256) continues stating that ‘There is little doubt that creativity is a required element of improvisational working, and Highsmith (2004) identifies that within APM, there is a tension between structure and creativity, and that too much structure can stifle creativity’.

• Intuition: is a critical aspect in the definition of APM. Defined as individual level choice made without formal analysis. The pressure to deliver against challenging deadlines is common, and time to apply formal analysis to decisions or choices is limited, an intuitive, rapidly executable solution is therefore often sought.’

Leybourne (2009: 256) continues by stating ‘both improvisational working and APM draw on an intuitive feel for what will work in a given situation, and it is suggested that experience and the build-up of tacit knowledge over time will assist the project manager or project team member in assessing how to meet the often undocumented requirements of a specific situation’.

• Bricolage: the term describes the requirement to make do with those materials that are to hand, and as improvisation within the project domain often requires rapid action to meet unforeseen requirements there is little opportunity to mobilise additional resources.

Many large multidiscipline mining projects as we will see, are undertaken in remote areas where the mobilisation of additional resources or materials will be onerous and costly if not impossible.
The term bricolage could be applied to the ‘in project’ application of equipment, plant and the human resource. Leybourne (2009: 527) identifies the following aspects thus:

- **Adaption:** is a construct of improvisation. Adaption, the definition of which revolves around the adjustment of a system to external conditions which can be pre-planned, and is often a manifestation of planned work.

- **Compression:** is a time-based action defined as shortening and simplifying steps in order to reduce tasks or the total process. It is applied to reduce time taken to carry out tasks and activities, and by definition, to shorten the total project time-line.

- **Innovation:** as deviation from existing practices or knowledge, it can be argued that all organisations innovate in some way, either with product, process, or managerial application.

- **Learning:** which can be experiential or more formalised. The systematic change in behaviour or knowledge. It can be spontaneous, or it can be planned, and within improvisational working.

Critically Leybourne (2009) states ‘There is much literature that identifies a tendency to disband project teams early, before learning from a retrospective review of project activity has taken place. It is however one of the strengths of project-based work that there is a review and feedback phase, where inter and intra-team learning can be formalised’.

In a large multidiscipline mining project there is a tendency for the team to be reallocated and disbanded in a progressive manner as the project moves into different phases and as packages are completed. The review and feedback phases should thus be instituted from the outset.

In conclusion Leybourne (2009: 531) states ‘It is evident that, notwithstanding the rapid evolution of both the improvisation and APM literatures, there are a number of parallels that can be identified, and that given the increasing turbulence in the environments within which organisations are seeking to survive, and the need for responsiveness to exploit opportunity in changing markets, agility and improvisation are required attributes’.

With agility being an aspect of innovation in project management, Fernandez and Fernandez (2008: 10) state that ‘Traditional projects are clearly defined with well documented and understood features, functions, and requirements’. ‘In contrast, agile projects discover the complete project requirements by doing the project in iterations and therefore reducing and eliminating uncertainty’. ‘Because of this, agile project management tends to be higher risk compared to traditional projects, but agile project management has the flexibility to more easily adjust to changes in project requirements’.

From Fernandez and Fernandez (2008: 10) ‘conventional methods of project management (PMBoK®) can be inappropriate and potentially disadvantageous for projects that are structurally
complex, uncertain, and heavily time limited'. Fernandez and Fernandez (2008: 11) provide the following list of criteria:

- Assume simplicity,
- Embrace change,
- Enable and focus on the next effort,
- Incrementally change,
- Maximise value,
- Manage with a purpose, question actions,
- Project Manager must manage the project and process boundaries,
- Rapid feedback to all stakeholders,
- Quality deliverables,
- Create documentation based on value.

Fernandez and Fernandez (2008: 11) recount agility as a "thought process" with the following practices:

- Think in small incremental deliverables,
- Get the customer in the game,
- Have continuous QA at every point through assurance process,
- State up front requirements are fluid - build the processes around fluid requirements.

Fernandez and Fernandez (2008: 11) discuss their strategies for agile project management as being:

<table>
<thead>
<tr>
<th>Linear Strategy: is a traditional strategy that consists of dependent, sequential phases that are executed with no feedback loops. The project solution is not released until the final phase.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental Strategy: that is identical to a linear strategy except that each phase of the project releases a partial solution. The characteristics of this strategy are identical to the linear strategy except that business value must be delivered prior to the final phase.</td>
</tr>
<tr>
<td>Iterative Strategy: that consists of a number of repeated phases that include a feedback loop after a group of phases is completed, the last phase of a group may include a partial solution if the customer desires. The Iterative strategy is a learn-by-doing strategy that uses intermediate solutions as a pathway to discover the details of the complete solution.</td>
</tr>
<tr>
<td>Adaptive Strategy: that is similar to an Iterative strategy except that with an Adaptive strategy each iteration's feedback adjusts the next iteration so that a solution will be converged upon. An iteration can release a partial solution at the discretion of the customer.</td>
</tr>
</tbody>
</table>

The incremental strategy would be similar in some situations to the large multidiscipline mining project, where at some interim points items of completed infrastructure would be released to the client or other contractors for use.
Extreme Strategy: that is similar to an adaptive strategy except that instead of adjusting with each iteration to converge upon a solution, the goal of the project must also be discovered and converged upon. The lack of goal clarity is the main difference between the Adaptive and Extreme strategies. The Adaptive strategy requires a clear goal and the Extreme strategy does not.

Figure 3.1 is shown below to illustrate the project management strategies to manage increasing complexity and uncertainty in execution of the project.

![Project management strategies](image)

Figure 3.1 - Project management strategies based on complexity and uncertainty, from Fernandez and Fernandez (2008: 14)

Fernandez and Fernandez (2008: 15) compare and discuss the contrasts between the traditional and agile project:

Traditional Versus Agile Projects:

‘Traditional projects are clearly defined, well documented and contain understood features, functions, and requirements. Agile projects discover the complete project requirements by doing the project in iterations and therefore reducing and eliminating uncertainty’.

Traditional Versus Agile Project Management:

‘Traditional project managers manage their projects against the budget, schedule, and scope. Metrics and variance can be tracked against the planned baselines. The traditional project manager wants to reduce risk and preserve the constraints of time and money. In contrast, the agile project manager is focused instead on deliverables, business value - budget and timeline are secondary. The agile project manager is trained to deliver a product instead of adherence to a process like the traditional project manager’.

For the EPCM Company this would require a client that also understands the principles of agile project management and the necessity to apply the principles effectively.

Traditional Versus Agile Teams:
Traditional projects can more easily support distributed work teams of specialists and junior members because of the well-defined requirements and other documentation. Agile project teams require co-location of team members and staff in order to embrace change and rapidly produce increments. Projects being worked in multiple locations can have teams using agile methods in each location. The commitment level from agile project team members must be greater than from traditional team members as they are called upon to take a greater role in their projects.

For the EPCM Company working on International projects from various locations this would require additional effort from the management team to ensure the dispersed teams are both agile and effectively integrated.

In this section, expanding on the ‘last planner theory’, the application of agility in project management was examined. Though possibly counter-intuitive for the EPCM company where consistent success is based on the application of tried and tested system, both theories require the deconstruction of the project management processes and the application of flexible and versatile project management processes.

3.5 Project systems

There are many systems available to the manager, amongst these are the project systems. In the light of the preceding two sections of chapter three there is a review of literature regarding the necessity for the broader application of project systems.

Eve (2007: 85) discussed the need for organisations to synchronise the development of their complete project management system. Eve (2007), sees that there is a trend in the movement of the world’s best companies towards adopting project management as a generic way of working rather than simply a sub-methodology or process. ‘Project management is seen as a key enabler with which companies adopting business improvement methodologies such as ‘Six Sigma’ or lean manufacturing improve their efficiency and competitiveness’. In fact, project management is see as a core competency and as a necessity for a company to maximise the effect and benefits the lean manufacturing and six sigma processes.

It could be seen that for the EPCM Company there would be a distinct benefit theoretically to embrace project management philosophies throughout the organisation, this would engender a greater understanding of the operational challenges throughout the company.

Wyngaard, Pretorius and Pretorius (2012) discuss the triple constraints of time, cost and scope. Projects are under pressure to be completed quicker, cheaper and better, projects are becoming the way to do things in more and more companies, and represent significant portion of international investment. According to Wyngaard et al (2012) these constraints have to be managed may condemn the project in spite of managing the project successfully with regard to the other project constraints.
management aspects. Wyngaard et al (2012) propose an integrated model to manage the triple constraint trade-offs. The typical project measures of time, cost and scope fail to appreciate the strategic ambiguity and more relevant project goals. Wyngaard et al (2012) suggest that the client’s key objectives for the project are identified, some of the project constraints may be more flexible than others. These are the aspects that can be flexed other constraints may be inflexible and key to the project success. The model developed enables the project manager to exploit the triple constraint and maintain a focus on the primary project purpose. In the large multidisciplinary mining project there could be many primary goals and each could have a triple constraint.

The broader application of project management techniques with in the EPCM Company would have the benefit of developing a larger understanding of the necessity to achieve business objectives on time, on budget and to achieve the objectives the activity was undertaken for.

### 3.6 Project control in uncertain environments

Continuing on the theory of agility in project management comes the project management practices required for the management of uncertainty in project definition and project execution.

The large multidisciplinary mining project is poorly defined from the outset of the project. These uncertain environments create additional challenges for the project execution team and thus for the project manager. The following articles were identified and discuss this effect of this uncertainty and the processes be suited to assist in managing this uncertainty.

Bourne and Walker (2005: 157) review the decision making process within a complex organisation. The authors reflect on the need for a new approach to decision making, moving away from the traditional command and control management style. Their paper shows that a theory shift in management processes is needed to succeed in managing projects and their teams within the unsettled environment of a modern matrix organization. Bourne and Walker (2005: 158) cover the following in their text: 'increased complexity has consequences for organisations and their people. These consequences impacted on the individual’s increasing uncertainty about their role where the resultant anxiety lowered productivity, leading to an increasing focus by the organisation’s senior management applying more and more control. The challenge now for project managers is to deliver successful projects in a climate of change and uncertainty within an organisational framework that responds to this change and uncertainty by imposing more control'.

This environment could be said to exist in the multinational EPCM Company delivering large multidisciplinary mining projects.

In discussing the paradox of project control Bourne and Walker (2005: 159) recount success in this environment requires a different management model from that developed for management in more predictable project settings. ‘The paradox of project control is that the project manager must
be vigilant in controlling the outcomes of the project in the prevailing climate of change and uncertainty where the project manager and the project stakeholders are affected by the same change and uncertainty’. The project must continue according to the agreed budget, schedule and scope while functioning within an organisation where deviations from plan are viewed by senior stakeholders as being a project “out of control”, and where management reaction to regain control will most likely result in instability within the project. ‘This instability can be in the form of the resignation or removal of team members, new reporting requirements or a requirement to maintain the original budget, schedule or scope even though conditions external to the project, but affecting its ability to deliver on time, budget or within scope, have changed dramatically’.

These concerns will be familiar to the project execution team within a large EPCM company. This could be viewed as management induced tipping points within the project.

Bourne and Walker (2005: 159) discuss the contradictory ‘chaordic’ system which is best defined as being organised chaos. As the authors state, ‘Chaordic: is defined as anything that is both orderly and chaotic at the same time, that has a pattern dominated by neither order nor chaos’.

For Bourne and Walker (2005: 161) implication of environmental complexity within a project management context is that to succeed, project managers must establish and maintain relationships with many stakeholders both within and beyond the project management organisation. Additionally Bourne and Walker (2005) discuss the distinct need for the project manager to maintain a full overview of the project:

- Managing the team and colleagues,
- Monitoring the project,
- Looking outwards to the client and the supply chain,
- Looking upwards to the sponsors,
- Applying forwards strategy.
Bourne and Walker (2004) captures this philosophy in the following diagram, figure 3.2:

Figure 3.2 Dimensions of project management: Bourne and Walker (2005: 161).

Bourne and Walker (2005: 162) discuss briefly the need to address sharing and accessing knowledge, this appears many times in project management literature. Covering at the same time the team needs, communication and knowledge management.

Bourne and Walker (2005: 165) discuss the popularity of the matrix organisation for project managing entities, ‘Matrix organisations focus on multiple relationships. For the project manager operating in a matrix organisation, the task of successful project delivery will be complicated by multiple reporting relationships for project team members’. The matrix organisation, which is popular in the EPCM Company environment therefore presents considerable challenges to the project manager in developing a project team. Bourne and Walker (2005) added project ambiguity to the project discussion:

- Uncertainty with the problem,
- Uncertainty as to what is really happening,
- Uncertainty as to what is required,
- Inadequate resources,
- Role allocation is unclear,
- Operating procedures are not clear,
- Success criteria have not been defined.

In conclusion Bourne and Walker (2005: 175) state that a mind shift in management thinking is needed to succeed in managing projects and their teams within the turbulent environment of a modern matrix organisation. EPCM company management must be made aware that attempts to regain control over the project will be unpredictable. Project managers must be vigilant and
flexible. Management of project relationships and engagement of important stakeholders are keys to success in the dynamic environment of these organisations.

Uncertainty and ambiguity management is an aspect of project management in the LMM Project environment that requires understanding and a strategy to manage during project execution. If uncertainty remains unmanaged this can have a destabilising effect on the project execution team. The client’s role in the management of uncertainty cannot be understated and time has to be provided for the raising of uncertainty issues and the addressing of these with the client.

3.7 Managing multiple projects

Following on from individual project uncertainty comes the topic of managing multiple projects. It has become a necessity to be able to manage multiple projects; the large multidiscipline mining project is to all intents a multiple project with all the complexity that ensues and with the scarcity of resources the project manager may be required to manage more than on project. One article was identified that addresses the multiple project specifically and it is reviewed here.

Dooley, Lupton and O’Sullivan (2005) discuss the intricacies of managing multiple projects. It has become an operational necessity in many cases to be able to manage multiple projects at different stages of the project life cycle. In many instances the management of a long duration complex project will, during the course of that project execution experience many of the challenges that face multiple projects. From Dooley et al (2005) multiple projects need to be viewed as an integrated portfolio rather than a disjointed collection of projects. Dooley et al (2005) state that in managing multiple projects the project manager is required to maintain control over a range of specialist projects, coordinate often conflicting requirements with restricted resources and co-ordinate the portfolio to ensure the ideal outcome is achieved.

Some of the challenges according to Dooley et al (2005: 468) include:

- ‘Projects have interfaces with other projects and day-to-day operations, sharing common deliverables, resources, information or technology across those interfaces.
- Projects must negotiate priority for resources on an almost daily basis with other projects and day-to-day operations.
- Projects deliver related objectives, which contribute to the overall development objectives of the parent organisation.’

For Dooley et al (2005: 469) one of the main challenges facing multiple project management lies in co-ordination of the portfolio or configuration management. Dooley et al (2005) promote the concept of a portfolio planning cycle above the control cycle of specific projects. This overall planning cycle creates a clear process of priority setting and resource allocation, balancing the interests of all stakeholders involved and realising the overall objectives. This portfolio cycle
endeavours to address the problem where a difference may develop between focus on objectives of the individual projects and the focus on the organisational objectives from the portfolio of projects.

Regarding control and communication Dooley et al (2005: 469) reflect on the added complexity resulting on the necessity to work on multiple projects and that is the difficulty of maintaining control and communication. ‘This occurs due to many organisations being unable to align the management of their cross-functional projects with their functional structure in an effective matrix.’ This challenge would be less prevalent in the third party project management arena. The functional structures developed to increase efficiencies within the departments have a counter effect of duplicating some resources and creating a departmental myopia. Dooley et al (2005: 470) summarise this as follows:

- There is confusion and conflict over roles and responsibility between project managers and function heads,
- The unsuitability of existing reporting and reward systems,
- The of assignment of scarce resources is a source of power,
- Ambiguity leading to reduced motivation and job satisfaction,
- Poor communication between the various parties.

Dooley et al (2005) also reflect on the problems associated with managing multiple projects as the reduced propensity for learning and knowledge retention. Learning and knowledge management is critical for organisational and project performance.

Dooley et al (2005: 472) expanded on this aspect thus, ‘Many projects undertaken by organisations are never analysed to determine how successfully they have been relative to their objectives.’ They stress the importance of tracking and monitoring projects in order to effectively manage the projects and evaluate their performance. ‘Currently there is little knowledge recovered by the feedback loop and as a result, organisations continue to repeat the same mistakes.’

Dooley et al (2005: 472) in summary state: ‘It is evident that the management of multiple projects is an issue which will face all organisations as they adapt to their changing environment and has its own challenges’. Organisations managing multiple projects needs to ensure that systems and processes are in place to adequately address these challenges in order to maximise the benefits for the organisation. This is a key project management aspect for the EPCM Company.

Dooley et al (2005: 480) in conclusion state, ‘The problems associated with the management of multiple projects are more than the sum of the problems associated with individual projects. As with any hierarchy, the management team is ultimately responsible for alleviating any project problems experienced by their subordinates, but they must also address the additional challenges specific to management of the portfolio.’
The LMM Project can be seen as many project being run at the same time, it may even be necessary to run an operational mine or plant whilst executing other aspects of the project. Therefore the management of multiple projects is an aspect of LMM Projects that requires consideration. The project team may be required to work on more than one project and the project in execution may be in more than one phase at the same time. The communication becomes more challenging and the project team has less opportunity for knowledge retention.

3.8 Relational contracting

Following on from the complexity of managing multiple project in the LMM Project environment particularly where new technologies and specialist skills are required comes the necessity for relational contracting.

Relational contracting visibly demonstrates a level of maturity between parties contracting to a common goal, one article was selected for review in this section. Baker, Gibbons and Murphy (2001) discuss the value of the relational contracts as the value placed on future business through this process. Though this article is written on the basis of intercompany relational contracts, there is relevance to relationships between firms and between client and firms. In the relational contract there is a focus on trust and partnerships, for example in the procurement of sophisticated systems and key items of plant there is a necessity to develop a relationship with the supplier to assure future availability and design optimisation.

Baker et al (2001: 1) state that relational contracts or informal agreements sustained by the value of future relationships ‘are prevalent within and between firms.’ Also according to Baker et al (2001: 1) ‘A relational contract allows the parties to use their detailed knowledge of their specific situation and to adapt to new information as it becomes available’. The relational contract is generally dependent on both the parties attaching value to the long term value of the relationship. This continued perceived value ensures both parties are unwilling to renege on the agreement.

The common relational contact for the owner in a large multidiscipline mining project environment would be where the client owns the asset and there is a relational contract in place. In this environment the client procures for his own use the item of plant and the control systems but there is an understanding in place for on-going technical support of this plant. Neither the client nor the normal support organisations have the technical knowledge to maintain or develop the more intricate aspects of this plant.

Referring again to Baker et al (2001) the other aspects of interest would be ‘Relational employment’ and ‘Relational outsourcing’, for the contact employment of personnel and temporary use of skilled personnel. Relational outsourcing the mining environment this would the provision of on-site testing facilities. The vendor would retain ownership of the plant used for the testing
services and the client would pay a fee for this facility and would pay for the use of this facility and the rates for the staff supplying this service.

Clearly relational contracts are informal but essential for the effective management of the business. Where there is a high degree of uncertainty in the execution of a complex project relational contracts will prove valuable. In the LMM Project there would be opportunities for relational contracting particularly where plant is of novel technology and a service agreement is not in place.

3.9 Fast-tracking

During the execution of an LMM Project there will come the necessity to accelerate one or more packages of the project in order to meet program requirements.

Fast-tracking or crashing a project is the compression of time lines and the overlapping of project activities to shorten the execution program. This is an established practice within the project environment, one article discussing this topic is reviewed here.

Bissiri and Dunbar (2001: 139) reflected on the perils and pitfalls of fast-tracking mining projects, ‘Fast-tracking is achieved through the compression in time of, and overlapping of, various phases of a project’. For the large multidiscipline mining project, this is beneficial if it brings the generation of revenue closer to the present-day, but it is an undertaking with risk that requires appreciation and mitigation.

Mining projects, particularly those where there is an increase in the capacity to produce mineral bearing rock or an increase in the beneficiation process involve significant capital and the utilisation of significant materials and personnel. It is inevitable that the investors would want to do as much as possible to bring in an early return on the capital.

According to Bissiri and Dunbar (2001: 139) the risks vary from scheduling and material supply problems to cost increases due to excessive compression of the project phases. The authors discuss the model required to better understand the risks and the relative economic benefits of fast-track strategies in mining.

They state that a model for computing the net present value of a fast-tracked mining project has been developed and it can be used to justify the decision to fast-track a project in terms of relative costs. Interestingly results from the use of this model suggest that there are some economic benefits in the use of modular mineral processing units installed as the mine is being constructed, these generate early revenue and become part of the final processing plant.

Thus the costs and risks associated with the fast-tracking of the project must be weighed against the possible benefits.
Bissiri and Dunbar (2001) state as we know mining engineering projects consume large quantities of time, resources and capital. They are executed in highly uncertain environments. Each project is a unique entity even if identical to another in design and scope, because of differences in time, location, economic situation, perceived future economic situation and financing. This exposure has as we have seen resulted in strategies aimed at reducing the time to start a mining operation. The application of fast-track techniques is one method of reducing the start-up time. Bissiri and Dunbar (2001) state ‘Fast-tracking a project may not only save time but also cut the overall project costs’. Bissiri and Dunbar (2001) have effectively summarised the challenges face by many large multidiscipline mining projects.

It is certain that there will be emphasis placed on the expediting of the project at some time during the project execution. This should be undertaken with the minimum exposure to risk.

Emphasis should be placed on modular plant design and for concurrency in construction, production and processing. As modules of the plant are completed they should as far as practicable be commissioned and placed into service. This becomes less feasible when moving away from a plant to a mining operation where the final commissioning is contingent on the completion of the entire system. Certain items of plant should as far as is possible be used for the sinking operations and for haulage development to maximise the use of this capital equipment and to minimise the use of temporary plant that will removed or discarded at the end of the project activities.

3.10 Large multidiscipline mining (LMM) projects

The LMM Project is time consuming are requires the application of considerable resources.

The article reviewed here discusses the continuing relevance of the large scale engineering project which can be transposed to the large multidiscipline mining project.

Hassan, McCaffer and Thorpe (1999: 21) reflected on the growing need for large scale engineering projects, they state, ‘In recent years the Large Scale Engineering (LSE) construction sector in Europe has seen profound change. This is mainly due to increasing competitive pressures from the United States and the Asian–Pacific countries which has led in turn to increased pressures to improve competitiveness, productivity and client satisfaction. Lack of understanding of client’s requirements hinders achieving such goals especially with the increasing trends of executing LSE projects in a ‘virtual enterprise’ environment. Different parties within the construction process need to understand and fulfil client’s business and information requirements. Information and Communications Technologies vendors and developers also need to understand client’s requirements of systems and to align their products to them’.
Most would be familiar with the definition of a Large Scale Engineering (LSE) project quoted in Hassan et al (1999: 21), for the purpose of this study this is considered transferable to the large multidiscipline mining (LMM) project. A large multidiscipline mining project has the following attributes:

- High capital cost,
- Long program duration,
- Programme urgency,
- Technologically demanding,
- Logistically demanding,
- Multi-discipline inputs from many specialists.

This leads to the establishment of a ‘virtual enterprise’ for the execution of the large multidiscipline mining project. Hassan et al (1999: 21) state that the ‘virtual enterprise refers to a group of organisations that collaborate in partnership to execute an LSE project’. This partnership may continue to operate and maintain the product until decommissioning, execute another LSE project, or be a transient virtual enterprise which dissolves once a project is executed or a facility is decommissioned.

Within the mining project comes the additional challenge of often being required to commission and operate some of the permanent structures during the execution of the project.

Hassan et al (1999: 22) reflected on the changes coming into the LSE environment as being:

- Placing more risk on the contractor,
- Greater technical input from the contractor,
- Risk and reward balance shifting,
- Non-core activities being outsourced by the client group.

The increasing trends according to Hassan et al (1999: 23) were specifically; partnering, private finance, increasing state regulation, risk allocation to the contractor, acknowledgement of contractor technical expertise, sharing of lessons and expertise, electronic documentation exchange, pressure to reduce project cycles, volume of information exchange. Obviously this was written at the start of the 90’s information explosion.

Hassan et al (1999) identified at that time that there would be a steady reduction in the expertise of the client and therefore a greater reliance on the technical expertise of the contractor. In their concluding comments Hassan et al (1999) predicted a shift in the ten years to strategic alliances and integrated supply chains. The client would be looking for a shift of the responsibilities and risk from the client to the contractor.
The literature reflects on the LMM and the LSE projects and the profound impact that these projects can have. The scale of these projects can test the resources of the client and the contractors. There is a trend towards sharing the risk with the contractors with specific contracting models being developed. Due to the nature of the LMM project the client often does not have the resources to execute using own resources and thus would look to contract in the resources required.

3.11 Project safeguards

The implementation of an LMM Project can be hampered by the necessity to commit the resources required to assure the success of the project. This can be eased by the embedding in the project early revenues and options in the form of project safeguards.

Project safeguards for the large multidiscipline mining project can add value to the enterprise in the concept, design and execution phase of the project.

Gil (2007: 980) defines a project safeguard as ‘the design and physical development work needed to ensure or enhance the embedding of real options in complex products or systems’. This was written around complex infrastructures such as airports, transport systems, power stations and process plants, but should equally apply to the large multidiscipline mining project.

Gil (2007: 981) states the necessity to keep the future options open as during the project lifetime there will be some changes that might impact on the design such as an environmental legislation update, increased demands in terms of output and earlier returns. The need for options to be built in to the project to leave room for expansions or different options into the future of the project as the project environment changes into the future. Such options would include such items as:

- Growth capacity,
- Phased development,
- Change in the operating regime.

Depending upon the options being exercised and the range of the development of these options is an indicator of the client investment should options not be exercised into the future.

In order to prevent premature future obsolescence safeguards need to be built into the design of the project to ensure options can be exercised at some future date. For Gil (2007) safeguarding is not so much keeping the design solution generically flexible. It is about seeing a potential future use. It is not there now, but it will be very expensive to implement it when it comes unless the project does a few things now which will have limited cost.

Then Gil (2007: 992) discusses the various options for passive to active safeguarding. In defining passive project safeguarding; passive safeguarding is defined as the allocation of space but no
investment in designs or facility, active safeguarding is the investment in space and facility so the safeguarding can be realised during the execution of the project.

Clearly there are options for safeguarding in large multidiscipline mining projects particularly where the costs of the safeguarding activity in the present construction are warranted by real savings to execute in the present program of activities.

Gil (2007: 995) continues by stating; ‘You must never build something unless you have a reasonable confidence it is going to be required, and when it is required it will be of the same size, shape, or whatever, particularly if you are building underground’.

Though obvious, safeguarding in large multidiscipline mining projects needs careful analysis particularly in the fervour of project execution to ensure passive safeguards are not converted to active safeguards unnecessarily. Safeguarding a project can add significant value to the project through creating early value and revenues, and adding future value to the project. Safeguarding can provide future options for the project to improve the project durability and longevity.

3.12 Estimating and bias

Following on from the project safeguards to add value to the project the project team needs to be acutely aware of the necessity to have realistic estimating to understand the realistic cost of the project and to be aware of the tendency for bias and information asymmetry to ‘sell’ the project.

Along with managing asymmetric information, estimating when developing a project budget is a critical aspect for the definition of the large multidiscipline mining project.

Lofton (2009: 03.1) reviews the challenges associated with estimating for the megaproject. Primary amongst these challenges is the scale of the project. Lofton (2009: 03.1) states, ‘With large projects, anticipation and organisation are the keys to successful estimating. Because of the sheer magnitude of these projects, a well-organised team is required to meet the estimating demands. That estimating team must have specific positions with roles and responsibilities well defined and understood.’

From Lofton (2009: 03.2) the typical project will require concept estimates, detailed estimates, study estimates, and scope change estimates. The concept estimate is the first view of the costs and will be based on the information that is available. The best information that is available is used to make assumptions of the scope and program. Where specific information is not available, industry or company norms are used.

During the evolution of the estimate many people can be involved for an extended period of time. The size of large multidiscipline mining projects will create unique challenges according to Lofton (2009). This creates challenges of scale for the project team and the local suppliers may react in anticipation of the arrival of the large project. Certain items will have to be purchased out of the
area causing an increase in supply costs. The size of the project will often influence the vendors; they could be reluctant to spend time estimating anticipating that the effort will be fruitless, and efforts exacerbated when there are repeated requests for versions of the tender and for validation of prices.

The sheer size of the tender list can cause administrative challenges for the capture of information, changes to the documentation will also present the challenge of inertia. From Lofton (2009: 03.5) for megaprojects it is important to understand what it will take to develop the project estimate. There will be numerous types of estimates required and the lead on these projects must support when estimates will be required and what resources will be required to fill the need. The unique challenges of size and time restraints can be met with proper experience and planning. ‘These large projects offer unique growth opportunities for new estimators’.

The large multidiscipline mining project would not be invulnerable to these challenges and will be exacerbated by the long lead times from budget estimates to possible execution, in addition vendors would be aware that the pricing would be used to generate a budget and costs may be inflated to create a contingency budget. Alternatively prices may be underestimated due to a lack of information as to the full scope.

Shore (2008: 5) states obviously that ‘Project failure rates are certainly cause for concern, but consider that more and more organisations are adopting a project-based model of organisation, called PBO, and it is not surprising to find that addressing failures and learning from them has become increasingly important’. They discuss the identification of project biases. Shore (2008: 9) identifies in table 3.3 below the systematic project biases:

Table 3.3 – Systematic biases: derived from Shore (2008: 9),

<table>
<thead>
<tr>
<th>Bias</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available data</td>
<td>A data-collection process that is restricted to data that is readily or conveniently available.</td>
</tr>
<tr>
<td>Conservatism</td>
<td>Failure to consider new information or negative feedback.</td>
</tr>
<tr>
<td>Escalation of commitment to a failing course of action</td>
<td>Additional resources allocated to a project that is increasingly unlikely to succeed.</td>
</tr>
<tr>
<td>Groupthink</td>
<td>Members of a group under pressure to think alike, and to resist evidence that may threaten their view.</td>
</tr>
<tr>
<td>Illusion of control</td>
<td>When decision makers conclude that they have more control over a situation than an objective evaluation of the situation would suggest.</td>
</tr>
<tr>
<td>Overconfidence</td>
<td>Level of expressed confidence that is unsupported by the evidence.</td>
</tr>
<tr>
<td>Recency</td>
<td>Disproportionate degree of emphasis placed on the most recent data.</td>
</tr>
<tr>
<td>Selective perception</td>
<td>The situation where several people perceive the same circumstances differently; varies with the ambiguity of the problem or task.</td>
</tr>
</tbody>
</table>
### Bias

<table>
<thead>
<tr>
<th>Bias</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunk cost</td>
<td>The inability to accept that costs incurred earlier can no longer be recovered and should not be considered a factor in future decisions.</td>
</tr>
</tbody>
</table>

Shore (2008: 7) gives the following definition of systematic biases:

> ‘Systematic biases represent common distortions in the human decision making process. They reflect a particular point of view that may be contrary to rational thought. Further, they are systematic in contrast to random errors that, on average, cancel each other out’.

A strategy reviewed by Shore (2008: 14) was to create a culture that reduces the fear of failure. One company ‘recognising that it may have gone too far in emphasising success and punishing failure, is now promising stock options to scientists who terminate unpromising projects. They say it is not the loss they are rewarding, but the scientist’s willingness to accept the fact that the project lacks promise’.

In conclusion Shore (2008: 13) states ‘there is a long tradition in the organisation psychology and decision making literature that focuses on the study of systematic biases. There is also a long tradition in the project management literature that focuses on project failures.’ Shore (2008) attempted explain how the corporate culture may provide the environment for these failures to occur. If the project is subject to a rational oversight of project management this may be sufficient to assure project success.

Bertisen and Davis (2008: 118) reviewed the aspect of ‘Bias and Error in Project Capital Cost Estimation’. They state, ‘Previous analyses of small samples of mining projects have found that feasibility studies tend to underestimate the as-built capital costs of the project’. Bertisen and Davis (2008: 118) identified that projects come out, ‘14% higher than as estimated in the bankable feasibility study’. This has not varied over time indicating a lack of corporate learning or a desire to win the project execution. They argue that this is not by accident but, this consistent bias is intentional, driven by a desire for project financing and to bias the project economics.

Bertisen and Davis (2009: 118) continue stating that, ‘roughly half of all projects’ as-built capital costs fall outside of the expected ±15% of the feasibility study capital cost estimate, even after allowing for intentional estimation bias’. ‘Cost overruns of 100% or more happen in roughly 1 out of 13 projects’. Smaller projects have less propensity for cost overruns’. Continuing Bertisen and Davis (2009: 119) reflect on the previous studies that have identified the underestimation that plagues megaprojects. Forty seven megaprojects undertaken between 1965 and 1985 came in an average of 88% over budget. Analysis showed factors such as scope changes and unplanned inflation as being the drivers of these cost overruns. Cost overruns due to inflation were particularly attributed to the State and World Bank projects.
When examining mining and mineral beneficiation projects in particular, though there is an element of cost inflation the studies reviewed by Bertisen and Davis (2009) identified a downward bias in the initial feasibility study estimates. Out of a set of 63 projects studied by Bertisen and Davis (2009), 44 had underestimated the capex requirements with an average of 25%. Is there a reason for this consistent underestimation of the capital required for the execution of projects in the mining industry? They state ‘persistent overruns could be the result of deliberate deception in an effort to advance costly projects.’ According to Bertisen and Davis (2009) engineers and managers in the mining industry have strong incentives to underestimate capital costs. This incentive is not to develop uneconomic projects but is due to a continuous excess demand for finance in the mining industry. ‘Simply put, in any given period there are more positive net present value (NPV) mining projects that require financing than the financial market is willing to support’.

There is obviously a need to ensure the project that is being proposed is given a good representation when it is compared with others seeking funding. So there would be a great deal of pressure to under represent the capital requirements and over inflate the economic benefits.

Bertisen and Davis (2009: 125) reflect on the industry that plies underestimation as a means to gain finance, underestimation persists because of information asymmetries, learning barriers, and coordination problems. The engineering consultant preparing the cost estimate and the project sponsor have better and more information about the costs and production potential of a project than financiers. ‘Financiers, unable to view the true capital costs of the project, are unable to determine whether a sponsor has understated the capital costs and, if so, by how much’. The assumption is that all project sponsors underestimate costs. Each project sponsor, knowing that others are deflating their capital costs, must do the same to remain competitive. Therefore, there is the perception that all mining projects are subject to underestimation of the capital requirements and the financiers will therefore be able to select the project for financing on the basis of the information presented.

Bertisen and Davis (2009) reflect on the prevalence verses the competition for the capital. This reflects on the capital deflation in big verses small projects, in the various commodities and with established verses newer companies. For example bigger mining houses (Senior Miners) in the gold sector have less competition for capital and are less likely to deflate the capital requirements to compete for finance. The analysis indicated that the smaller the project the greater the tendency to underestimate.

Bertisen and Davis (2009: 136) state; ‘Analysis of 63 worldwide mining and smelting projects completed between 1980 and 2001 indicates that feasibility study capital cost estimates contain both bias and error. The average percentage overrun is 25% when as-built costs are measured in actual (nominal) dollars and 14% after as-built costs are adjusted for estimated cost inflation’. There are of course many possible extenuating circumstances that can contribute to cost overruns.
but the consensus is that with many years of experience these could have been mitigated and in some circumstances eliminated.

Bertisen and Davis (2009: 136) continue, ‘Though other authors mainly suggest unexpected design problems as causing the overruns, the persistence of the bias over four decades does not support their assertion’. They conclude that the bias is intentional due to a persistent excess demand for project finance, with consultants acting rationally, and an implicit agreement with project sponsors to underestimate capital costs.

This represents a certain level of conspiracy during the compilation of budget costs, possibly contributed to by the vendors selected to supply the costing into the budget. All parties have contributed to the underestimation of budgets and the financiers lack the resources and skills to perform the level of due diligence required to thoroughly interrogate the budgets provided.

In the competition for project approval and for project financing there is a conscious need to understate the costs and possibly a need to overestimate the possible returns. This aspect could attract additional scrutiny; the returns could fall into a domain that is outside the scope of the project organisation. The financiers probably take the view that all projects are similarly misrepresented when submitted for adjudication and thus the better project would thus be apparent from the information submitted. Larger more experienced sponsors have less resistance to funding and the financiers offer less resistance understanding that the funding risk is far less.

Flyvbjerg et al (2009: 175) discuss the external manifestation of delusion, which is the deception. They state that ‘deception- accounts for flawed planning in decision making in terms of politics and agency issues’. ‘The political and organisational pressures in executive decision making involve the principal agent problem and the sources of strategic deception.’

Flyvbjerg et al (2009: 180) state that the ‘key to minimising delusion is to have a good learning environment’. Repeatedly encountering the same problem embeds the possible outcomes. Delusion and deception is similarly present in the large multidiscipline mining project, asymmetric information dissemination regarding the project is prevalent when presenting the project to the financiers. When the project is competing for capital it is beneficial to the project team to represent the project as attractively as possible.

According to Flyvbjerg et al (2009) some approvers apply an automatic (optimism bias) uplift in terms of the budgets and programs. Some UK Government Departments insist on a local or regional contribution to project funding to share the risk. This has had the effect of generating more realistic programs, more realistic benefits and more realistic budgets.

That there is a natural bias to underestimate costs and underestimate the execution duration is without doubt. It is almost certain that this is due to an eagerness to gain approval for the project. There is also certainly a bias to overestimate the potential return and a corresponding propensity to understate the risks that come with the project execution; these manifesting risks could add
extra costs during the project execution, impact on the returns or delay the project execution. These aspects could be the topic of future research on project execution. The estimating processes employed to arrive at a budget for the LMM Project could also tend to underestimate the cost of the project.

To go into project execution with all of these hidden challenges would hamper the project execution team for the entire project duration and result in a project that is late, over budget and ultimately unable to meet the business objectives when reaching full production. The client would have to commit to further investment to meet the objectives often incurring additional delays.

3.13 Forethought

Often during the inception phase of the project fundamental project flaws will be known to the project team but go unvoiced due to group think and a reticence to voice these concerns.

One article was identified that discussed the project premortem as a distinct process as opposed to the established risk assessment process.

According to Klein (2007) projects fail at a spectacular rate, one reason being that many people are reluctant to raise their reservations during the planning phase. By making it easier for these persons to raise their concerns in the inception of the project will improve the project chances of success. Klein (2007) developed the term premortem as a project improvement technique.

In differentiating the premortem from the more traditional risk assessment Klein (2007: 19) states, ‘Although many project teams engage in prelaunch risk analysis, the premortem’s prospective hindsight approach offers benefits that other methods don’t’. The premortem helps teams to identify potential problems early on, it also reduces the influence of ‘overinvested’ persons. As a secondary benefit team members feel valued for their experience and project input, and other team members learn from them. The premortem exercise also causes the team to pick up early challenges once the project moves into execution.

3.14 Project risk

Risk is well documented in the standard texts on project management. There is no intention to explore the well documented areas of project risk and there are many well established packages that can assist in identifying and categorising project risks.

There are however new risks embedded in the LMM Project environment and a certain amount of risk management fatigue that have relegated risk management from being a fundamental management responsibility into a second tier activity.
Twenty articles are reviewed here that explore novel risk aspects in the construction and engineering project environment.

Edwards and Bowen (1998: 339) reviewed the current literature on construction project risk management and identified trends for future research on this topic. Continuing Edwards and Bowen (1998: 339) identified growing appreciation in the importance of risk management for effective project management from the inception of project management as a discipline in the 1960’s, particularly driven by manned spaceflight. Edwards and Bowen (1998) reviews the topics of natural and human risks as applied to the construction environment. Natural risks being the weather and geology, and human risks being effectively the ‘social, political, economic, financial, legal, health, managerial, technical and cultural elements’. This is effectively everything else that the project execution encompasses.

In conclusion Edwards and Bowen (1998: 347) conclude that people based risks are governed by subjective probabilities, heuristics and biases. The development of the risk profile would require the application of risk profiles and risk attitudes. They discuss the risk learning and communication of risk amongst the multiple structures and organisations of the construction project. This is an area that would bear additional academic research.

Developing this theme Regev, Shtub and Ben-Haim (2006: 17) they describe a new approach of managing ‘knowledge gaps’ for dealing with technological projects, the gap between what is known and what should be known. Regev et al (2006: 18) continue stating that ‘In technological projects, focusing on the reduction of major technological as well as logistical knowledge gaps is essential’. By concentrating research and development efforts on these knowledge gaps, a consistent effort possible. To parallel with the large multidiscipline mining projects perhaps the focus should be on the gaps in project understanding as the scope of these projects unfolds.

Regev et al (2000: 24) conclude by stating, ‘The management of risk is based on the philosophy that it is better to be proactive in managing projects rather than to be reactive. By identifying the sources of risk early on in the project life cycle and by focusing on the major sources of risk, management can select the proper policies for handling the risk’. They say policies include risk removal, by selecting a different design approach or a different technology; risk reduction by using redundancy in the design; risk sharing by outsourcing to a partner or a contractor with better knowledge of the systems; and risk reduction by using proper time- and budget-buffers. ‘These policies are all dependent on proper risk quantification. In some projects past experience is a good source of information for risk quantification’. Knowing the frequency at which a particular risky event occurred in similar projects in the past and the effect of such an event on the project’s success is the best source of information for project risk quantification. The method helps managers focus on the high-risk areas of the project and to take the appropriate steps to manage and mitigate such risks. In summary, this paper develops the following ideas.
Robustness: in the information gap approach, is the greatest magnitude of uncertainty variation that will not cause project failure. A project with high robustness is very immune to uncertainty and thus has low risk. A project with low robustness is very vulnerable to failure and thus is risky.

Opportuneness: from an information gap perspective, is the least level of uncertainty which enables, but does not necessarily guarantee, a highly desirable windfall reward. A project is highly opportune if windfall is possible even at low uncertainty.

Decisions: The information gap methodology provides the planner with decision functions for evaluating the decision variables with respect to robustness and opportuneness. This is the basis for making desirable operational and planning decisions.

Clearly there are distinct similarities with large multidiscipline mining projects where there are distinct uncertainties in the execution of the project that present a certain risk to the execution team. These have to be identified up front and managed through the versatility of the execution team.

The foregoing is reinforced by Busby and Zhang (2008: 86) as they state that ‘project risk analysis has traditionally emphasised the analysis of external threats’. They argue that the internal decisions and project structures are more fundamental as these determine how the external threats are managed. ‘This analysis goes beyond earlier work on organisational pathogens by treating them as subjective interpretations, not objective conditions. The study suggests that the more insidious risks to which a project is exposed involve different project members holding contradictory beliefs about what is pathogenic and what is protective’.

For a view on specific project risks Ogano and Pretorius (2015) discuss the infrastructure projects in Africa. Many have run into delays, quality problems and cost overruns. Though they discuss electricity projects, the framing of the project was as complex dynamic systems with multiple feedback processes and non-linear relationships. Understandably they identify political risks and multitasking as being prevalent in Africa, the underperforming infrastructure the projects seek to rectify imposes financial burden and inefficiencies. They note that here is still a lack of prescribed methods for identifying the interaction between social, technical, economic, environmental and political risks with regard to all complex and dynamic conditions of megaproject construction to enable effective management. Ogano and Pretorius (2015) also describe the non-linear behavior, non-linear feedback of complex socio-technical systems resident in megaprojects. These systems cannot be analysed in isolation, they have to be analysed as a complete entity. Ogano and Pretorius (2015) illustrate some of the characteristics of risk tipping point crises where the non-linear behaviour of some risks add to the risk burden of the project resulting in delays and cost overruns.

Examining the petro-chemical construction against construction projects in general, Van Zyl and Pretorius (2015) set out to identify risk categories to compare risks in projects to develop common risk categories. Against the backdrop of the construction of football stadiums for the Soccer World
Cup in 2010, the Gautrain project and the new power station build, the project environment was also facing skill shortages in particular engineers, power shortages and cost escalation. The study was no conclusive but indicated that the risks present in petro-chemical construction project could be more riskier than the risks present in construction projects in general. This would be an interesting study to perform in the large multidiscipline mining project, particularly as some of these projects are long duration and have an ongoing scope definition.

Parker and Mobey (2004: 18) discussed the high risk items that that are missed in the early stages of project excitement and later prove to be the downfall of the team and thus the project. Continuing Parker and Mobey (2004: 19) state that ‘project teams use approaches that may not capture project processes, contexts, rationales, or artefacts in a way that enables new project members to familiarise themselves quickly with project history and hence vital project knowledge is lost’. Parker and Mobey (2004: 20) state that risk assessment requires:

- ‘Identification of risk,
- Estimation of risk; importance, likelihood, severity and impact,
- Analysis and evaluation of risk to determine acceptability’.

Parker and Mobey (2004: 22) discuss the human factors affecting the risk management as the following; stress avoidance risk situations, self-esteem, complacency, predictability, trust and relations within the company, and the organisations readiness for change. According to Parker and Mobey (2004: 27) ‘At all levels of the population group, there was a poor self-understanding of how effective evaluation and analysis could be used to anticipate potential risks and thereby minimise project failure.’ ‘There was a clear lack of formal change management procedure and projects lacked sponsors and owner champions. The perception generally held was that projects were poorly communicated throughout their life cycle.’

Parker and Mobey (2004: 27) continue thus, ‘Better communication and identification to stakeholders of benefits of the change were perceived as a means to reduce resistance’. ‘There was evidence of a lack of understanding and appreciation of the reasons for change, lack of trust of management decision-making, and a low tolerance of the expected changes’. ‘The lack of risk management and assessment appraisal was associated with an unclear view of project ownership and insufficient clarification of defined responsibilities.’

In the concluding comments Parker and Mobey (2004: 28) tendered the following comments, ‘stakeholder participatory involvement during decision making, development, planning and implementation were identified as highly significant.’ This is as relevant for the large multidiscipline mining as it is for the IT industry where this article was written. All of these comments though pertinent are condemning of the approach to risk identification and management in the EPCM Company environment. For the internal processes of the EPCM Company there could certainly
be internal power struggles, this would not necessarily affect the performance on the large multidiscipline mining project.

For the EPCM Company projects moving into the international arena, Arrow (2008) tables a point of view that states, ‘Globalisation over the last decade has encouraged the pursuit of international projects for companies seeking to gain an international footing. By virtue of the fact that these players are operating in more uncertain environments, there are consequently much higher levels of risk that they need to manage. Additionally, with multinational construction companies taking more of a project management role, most construction work is undertaken by subcontractors resulting in many points of responsibility, greater problems of risk communication and less control over the way in which risks are distributed over the supply chain.’

Chan J, Chan D, Lam P and Chan A (2010: 1) ‘Preferred risk allocation in target cost contracts in construction’ state that ‘The problems associated with the traditional procurement approach have manifested in the form of cost overrun and adversarial working relationship between employer and contractor, especially in case of competitive fixed-price lump-sum contracts (Lahdenpera (2010)). It is suggested by Lahdenpera (2010) that gain-share and pain-share affecting the success of the entire project make the employer and contractor consider each other’s views better and collaborate more efficiently. Ingirige and Sexton (2007) held similar notion that the objective of a target cost contract (TCC) is to motivate contracting parties to lower the cost incurred without affecting the quality or delivery to maximise the contractor’s profitability and client’s savings’. These adversarial relationships will be familiar to anyone working for an EPCM Company on a large multidiscipline mining project.

Chan et al (2010) developed the following familiar risk ranking table 3.4 from their research:

Table 3.4 - Impact of risk factors encountered with TCC/ GMP: derived from Chan et al (2010: 6)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in work scope</td>
<td>16.41</td>
<td>1</td>
</tr>
<tr>
<td>Insufficient design completion during tender invitation</td>
<td>15.46</td>
<td>2</td>
</tr>
<tr>
<td>Unforeseeable design development risks at tender stage</td>
<td>14.54</td>
<td>3</td>
</tr>
<tr>
<td>Errors and omissions in tender document</td>
<td>14.51</td>
<td>4</td>
</tr>
<tr>
<td>Exchange rate variations</td>
<td>14.49</td>
<td>5</td>
</tr>
<tr>
<td>Unforeseeable ground conditions</td>
<td>14.25</td>
<td>6</td>
</tr>
<tr>
<td>Actual quantities of work required far exceeding estimate</td>
<td>13.97</td>
<td>7</td>
</tr>
<tr>
<td>Lack of experience of contracting parties throughout TCC/ GMP process</td>
<td>13.91</td>
<td>8</td>
</tr>
<tr>
<td>Inflation beyond expectation</td>
<td>13.81</td>
<td>9</td>
</tr>
<tr>
<td>Unrealistic maximum price or target cost agreed in the contract</td>
<td>13.76</td>
<td>10</td>
</tr>
</tbody>
</table>
Chan et al (2010: 17) concluded by stating that ‘an in-depth understanding of the significant risks is an imperative in project delivery with TCC/ GMP contractual arrangements. Inadequate consideration of risk allocation may result in failure in achieving the stated project objectives upon completion.’

Mobey and Parker (2002: 202) state that ‘to increase the chances of a proposed system being successful it is necessary for a company to have a clear understanding of the potential risks, to systematically and quantitatively evaluate these risks (evaluating the possible causes and effects) and then based on this select the appropriate mitigation techniques.’ The well-established principle of risk management is therefore to reduce, remove avoid or accept the risk. The allocation of risk management is often ad hoc.

Mobey and Parker (2002) conduct a case study to show how effective risk analysis prior to execution can be used to prevent problems and how the risk process should be linked to the decision making process. Mobey and Parker (2002: 203) refresh the appreciation of the risk analysis process in the following three steps:

<table>
<thead>
<tr>
<th>Risk Identification: Development of an appreciation of all the potential risks,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Estimation: An assessment of the risk and ranking of the importance, likelihood, severity and impact,</td>
</tr>
<tr>
<td>Risk Analysis and Evaluation: Where the acceptability, actions to take to mitigate are evaluated.</td>
</tr>
</tbody>
</table>

Mobey and Parker (2002: 203) highlight the more recent phenomenon of technology risk, typical would be an information technology failure.

Mobey and Parker (2002: 204) also reflect human risks:
- Did the implementation, planning and execution of the new system consider change management to encourage flexibility and human behaviour?
- Did user resistance contribute to system failure?
- Did users feel threatened by the new system? For example, may this be due to change in job content, loss of status/ power, uncertainty or unfamiliarity or job insecurity.

Exploring this topic further Joubert and Pretorius (2015) examined port and rail type projects in South Africa. They presented a model using the Monte Carlo method to quantify risk and project categories in a portfolio of port and rail capital projects. This is to enable a portfolio wide view of projects at to enable the project manager to determine ‘what matters most’ so that the risks can be effectively prioritised. The process involves creating a complete risk register using a common naming convention, and categorising the projects. The authors were able to determine the; programmes which cause the most uncertainty, the projects which cause the most uncertainty and their characteristics, and the relationship between programmes, risk category and project start delays. The results of this comprehensive study could be used to evaluate a group of projects to
identify the project to take forward into execution, evaluate a portfolio of projects in execution to prioritise or to prioritise risks in a large multidiscipline mining project.

Mobey and Parker (2002: 204) also reflect on the organisational risks they ‘attribute the high failure rate of re-engineering projects to cognitive, motivational and obligation based barriers to change’.

Expanding on the large engineering project discussion Gil, Tommelein and Schruben (2006: 426) debate the aspect of change in the execution of large engineering design projects.

Gil et al (2006: 426) state, ‘A problem facing the management of large engineering design projects is: Why do clients often adopt an early commitment strategy on design decision-making when they want to speed up project delivery, yet allow late changes to the project definition to accommodate the resolution of (un)foreseen external uncertainties?’

For Gil et al (2006: 426) ‘experiments demonstrate that when clients make commitments early on in conditions of high uncertainty, they increase the likelihood (upside risk) of speeding up delivery if external events do not materialise; however, if these events do materialise, they increase the likelihood (downside risk) of causing design rework and losing process predictability - especially when the ability to reuse design work after a change is limited.’

These situations are very familiar to the ECPM Company in the large multidiscipline mining project. Changes in management philosophy and changes in the project environment can cause fundamental changes to the design input.

Gil et al (2006: 426) continue stating, ‘moderate design postponement is appropriate if clients relinquish some of the upside risk of finishing the design sooner. Moderate design postponement does not increase the downside risk of overrunning the delivery completion date in relation to the risk clients incur when they commit earlier because it reduces expected variability in design. These insights highlight the client’s role in foreseeing external uncertainties and judiciously instructing changes to design teams. They also demonstrate the applicability of postponement to large engineering design projects where external uncertainty emerges as a fundamental contingency.’

Design activities should be completed as late as possible with an escalation from broad conceptual layouts. In the long duration project there would appear to be little to gain from pushing for a completed design where there could be a change in the design input, technology and client expectations.

Gil et al (2006: 426) recommend that ‘that project teams spend more time at the front-end examining options, testing scenarios, involving local/ user communities, and understanding the political/ economic environment. Applications of sequential decision models, similar to the real options approach, show that the greater the uncertainties at the onset of a large engineering project, the greater value of investment into gaining information on uncertainties as well as
deferring decision-making until uncertainties get resolved’. It is recognised that the execution teams rush the front-end to start working on licensing and financing activities.

In the large multidiscipline mining project, the design aspects would be initiated in a similar manner with conceptual layout being finalised with the mine client operational staff prior to the detail design activities being initiated.

Gil et al (2006: 436) continue ‘experiments show that when clients opt for early commitment in conditions of high external uncertainty, they increase the upside risk of reducing the concept development duration at the expense of increasing the downside risk of design reworking if external events unfold’. Gil et al (2006) highlight the necessity for the client to understand the risk environment of the project and then judiciously apply the design process so as to minimise the risk of rework of the design and to optimise the upside risk of completing the design activities ahead of time. ‘There are many examples of projects where there has been a desire of the client and or user to expedite the design process. The long rollout process has resulted in a significant change in the operating environment that has necessitated a fundamental design change’. The clients for large multidiscipline mining projects have to play a significant role in the initiative to expedite design aspects of these projects. There are gains to be had when adopting the early commitment to design freeze but this has to be weighed against the downside aspects of changes in the environment that would require a redesign of certain aspects.

From Gil et al (2006: 436) their ‘model suggests that a client’s decision to postpone design hinges on a combination of four factors:

- Urgency to complete concept development,
- Ability to foresee the timing and likelihood of externalities,
- Willingness to accept rework risk,
- The design team’s ability to reuse design work’.

Mining projects exist in an environment of uncertainty and technology advances that can add to the downside risk of design reworking. According to Gil et al (2006: 436) their ‘study shows, however, that clients bear a high design rework risk when doing so unless they improve their ability to plan for foreseen uncertainties and to judiciously instruct changes to the design team, especially if design reuse capabilities are low’.

The temptation to complete as much of the design of the project as possible is a risk that the client must carry particularly where the design aspects completed cannot be reused. According to Gil et al (2006: 436) ‘Moderate design postponement emerged as a viable option—provided that clients accept to relinquish some of the upside risks of early commitment—because it reduces the average amount of expected design rework without increasing the risk of overrunning the concept.
development schedule and budget in relation to the equivalent risk were commitments were made earlier’.

Also with the uncertainty regarding the design the estimates will have similar uncertainty regarding the pricing. To rationalise the early commitment strategy the EPCM Company has to entrench lessons learnt and develop internal project management capabilities so that the external project environment aspects can be embedded in the project decision making process.

The mining industry has demonstrated vulnerability to the external environment and the aspect of uncertainty. This clearly demonstrates the necessity to consider the aspect of design delays except where aspects of the design can be reused.

Gil et al (2006) ‘explain observable phenomena in large engineering design projects by factoring in the degree to which client-driven external changes affect the concept development process. External uncertainty does not equate to technical uncertainty or project size. This suggests one additional contingent dimension that may contribute to improve the completeness of work in project management typologies and in project failure’.

Baydoun (2010: 237) states that ‘Large-scale projects require a wide range of expertise that is rarely found within the developer’s team, especially in developing countries, for at least three reasons’. The reasons he gives are, Baydoun (2010: 238):

- Recruiting high calibre professionals from different disciplines is a time-consuming if not impossible exercise.
- Managing those professionals to come up with a coherent project team that meets the desired KPI’s requires an extensive experience that not all will satisfy.
- Formulating a team of this calibre will substantially increase the overhead costs unless this team is applied to multiple projects of similar nature.

These challenges face EPCM Company management, hence the need to share resources internationally, to carry out selective recruitment and to form specific alliances with other companies particularly in the project host country.

Baydoun (2010: 239) in a review of the risk management process states ‘the review of the literature shows the classic approach of risk management to be inappropriate for application to large-scale projects. The classical approach of risk management focuses on using databases of previous projects in order to predict potential risks. Based on that, an action plan is established to overcome these risks and a contingency budget is accordingly allocated. While this can be true for small-scale projects with limited number of parameters, it does not apply to large-scale ones. Large-scale projects are complex, with a high level of unpredictability and uniqueness, which renders databases from previous projects inadequate’.
According to Baydoun (2010: 240) the literature on risk management of large-scale projects promotes a reactive risk management approach as opposed to the normal proactive risk management approach. By reacting to risks as soon as they emerge the project manager will have to address the processes related to risks such as planning, implementation and monitoring as part of the daily activities, rather than focusing on monitoring the implementation of a predetermined risk management plan.

This would appear to be a form of ‘agile risk management’ where the risks are allowed to manifest prior to taking mitigating action. The project level risks identified by Baydoun (2010: 242) are:

- Market risks: changes in market assumptions about either the cost or revenue side of the project,
- Financial risks: not securing necessary financing for the project,
- Technological risks: introducing new technologies in the project,
- Management risks: managing complex processes of large-scale development projects,
- Completion risks: risks that can lead to non-completion of the project,
- Technical risks: the technical complexity of large-scale development projects,
- Operational risks: improper operability of the project,
- Armed conflicts risks: emerging from armed conflicts,
- Legal risks: impracticality of some existing laws and regulations in the locale of the project.

Many if not all of these risks identified by Baydoun (2010) are reciprocated in South Africa and are the risk environment for the large multidiscipline mining project.

Baydoun (2010: 243) identified the risks associated with the project environment as:

- Political risks: risks of political changes impacting on the project, for example, taxes or customs regulations,
- Social risks: lack of project acceptance by local community,
- Economic risks: these are related to changes in economic indicators,
- Environmental risks: the impact on the environment could lead to stopping the project.

In executing large multidiscipline mining projects the project manager could be faced with a project portfolio. Olsson (2007: 60) discusses the differences in managing a single project compared with that of a project portfolio and proposes a methodology for risk management.

Olsson (2007: 61) states that, ‘regarding project risk, there are different risks when viewing different perspectives of different stakeholders. In today’s highly complex project environment, there is clearly a need for better understanding of how projects are related to each other and what the implications may be of their interrelations’. ‘This is interaction complexity which refers to the
fact that the different process steps cannot be separated without affecting overall process performance (Sandhu (2004)).

Olsson (2007: 61) continues stating that ‘two areas are of importance when describing the implications for today’s management of risk and opportunities in a project organisation when handling several projects simultaneously’. ‘The first is existing risk management processes, and the second is the wider scope of project portfolio management than that of single project management’.

Olsson (2007: 61) reflects on the constraints of the current risk management process when applied to the multi project environment, ‘Most of the existing project processes are not developed to handle a portfolio of projects when considering risks and opportunities. This is due to the fact that the process structure does not assist in handling a portfolio of projects’. ‘In addition, existing risk management processes do not usually include functional risk management’. Functional risk is where a functional department is the origin of the risk, the function has to manage this risk.

Olsson (2007: 62) discusses the intuitive approach to project risk management that is often adopted in the experienced project organisation. ‘Experienced project managers, directors and executives intuitively balance project risks and opportunities’. Practical models and methods for risk management complying with this way of thought, and decision-making has shown that having a project view of uncertainties is not sufficient when managing them in a large, complex project-oriented organisation, a wider perspective must be adopted. This approach would be advisable when dealing with risks in the large multidiscipline mining project environment particularly where there are opportunities beyond the existing project.

Olsson (2007: 67) proposed the following portfolio risk analysis process:

<table>
<thead>
<tr>
<th>Step 1. Analysing project issues between projects. Analyse all issues for the selected projects. It is essential to understand the issues here since issue by issue the portfolio is analysed. This analysis step will reveal whether there are any common issues within the portfolio and if such common issues affect parts of or the whole portfolio.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2. Analysing one project’s issues with all the projects’ risk data (repeat for all projects). Comparing issues with extracts from the project’s risk register increases the level of complexity. The amount of data increases and sometimes the entered risks do not completely accurately describe the occurred issue, thus the importance of an experienced analyst. Firstly, the issues of projects in the portfolio are selected one by one. They are then compared with the risk register of the other projects. This will reveal if one project has any issues that, for other projects, are identified as risks. If such projects are separated in the project life cycle stage, the result could be used to avoid risks and/ or identify opportunities.</td>
</tr>
<tr>
<td>Step 3. Including risk data from all projects into the analysis. The last step in the analysis methodology is to compare risk data from different projects. This analysis is the most time consuming analysis, mainly because of the large amount of data. This analysis requires a common starting point of the analysis. Here, the product/ project configuration would come into use since this stage is based on stated hypotheses’.</td>
</tr>
</tbody>
</table>
To gain higher reliability of the results, additional portfolios could be included in the analysis.

This methodology acknowledges the importance of reviewing the results of the analysis with the respective project manager and project controller having the detailed knowledge. ‘In addition to validating the results, this review would reduce the “not-invented-here” syndrome. Therefore, it would also increase the acceptance of the analysis, its results, and the responses. The review should include assessment of the relevancy and accuracy of the analysis in terms of: cost exposure, risk trends and commonalities within the project, and the effectiveness of the risk response action.’

Olsson (2007: 68) developed the following examination of benefits for portfolio risk analysis benefits:

‘The benefits of the analysis can be viewed in three levels:

| Improvement of project risk and opportunity effectiveness: The comparison of risks between projects allows reflection and analysis of the situation and the adoption of risk mitigations actions. Thus, it is also possible to find common focus areas (e.g. for a production site, a product, or a function). Finally, this level will provide feedback and experience from other projects and their risk response actions. |
| Portfolio analysis benefits: This level of analysis will reveal portfolio common risks, and identify portfolio risk trends. Since projects usually are separated with regards to degree of completion within the portfolio, a risk in one project could be avoided in others. Finally, this level will assist with the identification of focus areas for performance optimisation improvement projects where opportunities could be realised. |
| Organisational benefits: If several portfolios within a company are compared, this level of analysis will identify risks that are common within all portfolios. These risks can either be related to a portfolio or to other, non-project specific, activities. Examples include the procurement process, the company IT infrastructure, or the HR process.’ |

In conclusion Olsson (2007) gives the following benefits to portfolio risk management:

| Greater visibility to senior management through the identification of commonalities and trends between projects within one portfolio, |
| Better prioritisation between projects since the portfolio and facilitating learning between projects; |
| More efficient and appropriate use of resources would be achieved by the identification of risk exposure of the portfolio and projects in most need of appropriate resources; |
| Better planning and coordination by the recognition of common risks and trends within the portfolio. |
| Explicit recognition and understanding of dependencies through adopting a portfolio perspective. |
| Improvement of risk and opportunity management effectiveness within the EPCM. |

Expanding on this theme of a busy large multidiscipline mining project Artto, Eloranta and Kujala (2007: 88) discuss the fundamentals of risk management with regard to the employment subcontractors.

As could be understood from Artto et al (2007: 88) relationships are developed with other sub-contractors, the client, and the competitors and with local bodies. Each or all of these could present a risk to the main contractor.

Artto et al (2007: 90) state that ‘in project risk management literature, risk is defined as the possibility that events, their resulting impacts and dynamic interactions may turn out differently than anticipated (Ward and Chapman (2003); Miller and Lessard (2001)). In this paper, we consider that the concept of risk can include the possibility of both favourable and unfavourable outcomes, but in the case of a risk with an emphasis on mostly favourable outcomes, we may replace the term risk with the term opportunity (Chapman and Ward, 2002: 2003).’

Artto et al (2007: 101) in conclusion state, ‘The risk of a subcontractor by-passing the contractor in the next project may also raise conflicting interests within the contractor firm’s organisation. This causes the harmful separation and disintegration of the project layer and the business layer even within the contractor’s organisation. For example, the project manager of the contractor firm may want to share information extensively and openly with the subcontractor, in order to guarantee the project’s success. However, the business unit manager or key account manager in the contractor firm’s line organisation may want to limit extensive information sharing with the subcontractor, in order to prevent the subcontractor from acquiring such information that would help the subcontractor to become a competitor that by-pass them in the next project.’

This is a situation that will be very familiar to the EPCM Company in the large multidiscipline project environment. The security of information has to be paramount but often difficult to maintain.

Kmec (2010: 1) states that the future state of the enterprise’s routines should be modelled early in the decision making process. ‘Attention should be paid to changes that major decisions, events, and projects impose on organisational routines.’ Kmec (2010: 3) generated a risk management overview thus:

- All risks are to be known,
- Risks are prioritised or the risk list is reasonably short,
- Risks are kept bundled according to some criteria,
- Risks are broken down hierarchically,
- Relationships among risks are captured,
- Risks evolution is modelled over time.

Kmec (2010: 13) presented the following implications, ‘The case study in this paper focused on movements that originate within the enterprise even if they are responses to external events. Other
evaluation tools, such as scenario planning, could be used far before an external movement would impact the organisation directly. In addition, the method presented here is not a substitute for cases where hard quantitative tools could yield better risk evaluation. One of the key ideas in this paper is that risks stem from contextual changes in the organisational routine due to major decisions, events, and projects.’

Beran, Dlask, Eaton, Hromada and Zindulka (2010: 190) examine and presents an approach for the improvement of risk analysis of construction projects. With this technique they link risk to the variances in cost or time schedule of endogenous variables, and they introduce the term ‘virtual management momentum’.

According to Beran et al (2010: 192) risk has grown into its own industry and has in parallel developed into the appreciation of entrepreneurship where risk is appreciated and managed. Additionally according to Beran et al (2010) risk analysis in engineering has evolved to the point where risk calculation can be considered to be satisfactory; however, there is still room for improvement in risk evaluation and risk management.

Looking at risk evaluation Beran et al (2010: 192) reflect on the three basic techniques for risk evaluation:

- Parametric methods,
- Simulation on the basis of classical input-output observations,
- Simulations on the basis of the Monte-Carlo method and pseudo-random numbers.

Beran et al (2010: 192) concentrates on the last two aspects.

Beran et al (2010: 209) conclude their report thus, ‘Organisational risk management is about improving the value of organisational decision making. It is necessary to think in terms of evaluating promising changes to existing cost and duration parameters and evaluating possible consequences or virtual possibilities or shifts of organisational strategies. It is a core management task to find a way to new efficient solutions.’ Beran et al (2010) propose graphically mapping the potential changes and their consequences that are dependent on tacit knowledge that is available from within the organisation.

One of the features of large multidiscipline mining projects is the tendency of the client to want to speed up the delivery of the project by committing to an early design decision when there is a distinct and often fulfilled external change requiring a change to that design. Savci and Kayis (2006) discuss the risks associated with concurrent engineering where the aim is to overlap processes in order to reduce the project execution period. Although faster design, development, and delivery are the intended outcomes, there is an increase in risk as a consequence of uncertainties between different dependent processes.
It is common in the EPCM Company environment particularly when working on studies and on the execution projects in the large multidiscipline mining project to experience extreme pressure in the opening gambit to run various project aspects concurrently. This will bring a risk element in to this scenario as various aspects will have interdependencies that may not be realised in this process.

Savci and Kayis (2006: 1) continue, ‘Risk Management Standards, as well as several published research articles have attempted to improve project and risk-management practices. For many years, the project and risk-management field have been oriented toward the long-range operations planning of projects, whereas the growing rate of diverse and unpredictable changes in technology and the environment, the increasingly demanding market, and international competition require frequent and effective management of product and process development.’ Though not directly aimed at the mining industry, it is inferred that the risk is not so much in the project and the project execution but in the effectiveness of the EPCM Company and Client Company processes.

Savci and Kayis (2006: 2) state that ‘That interdependencies between processes result in an increase in difficulties in the projects such as scheduling complexities which require effective project and risk management.’ The multi-site project will also add complexity and thus risk.

According to Browning and Ramasesh (2015) many projects face challenges that can be considered unforeseen, but this can be reduced if you know where to look. Browning and Ramasesh (2015: 53) start with the question ‘why do so many projects fail to meet their goals for time, cost and performance?’ Paradoxically even projects that use the latest techniques for risk management can encounter compromising risks. Those methods, while powerful, can only manage identified risks.

Browning and Ramasesh (2015) reflect on the prevalence of unknown unknowns in the project and how these aspects go unnoticed in the project risk assessments. According to Browning and Ramasesh (2015: 54) ‘many so-called “unknown unknowns” aren’t really unknown unknowns at all. Rather, they are things no one has bothered to find out. Indeed, there are two kinds of unknowns: unknown unknowns (things we don’t know we don’t know) and known unknowns (things we know we don’t know’). The authors discuss the subsystems (domains) where these unknown unknowns reside. The domains described by Browning and Ramasesh (2015: 54):

| Result subsystem: The desired result of most projects is a product, a service or some other deliverable. |
| Process subsystem: The work required to execute and manage a project is another type of system, one made up of activities, tasks and decisions related by the flow of information, work products and deliverables. |
| Organisation Subsystem: The people, teams, groups, departments and functions collaborating on a project represent another type of system. In many cases, this system breaks down due to what is often referred to as “poor communication.” |
| Tools Subsystem: To manage activities and transfer information, people in organisations need tools, facilities and equipment. |
Goals Subsystem: Most projects have goals for time, cost and performance (functionality, capability provided, quality, scope, etc.). These three areas often compete with each other.

Context: Every project exists within a larger context. A project may be part of a larger portfolio of projects, or it might have multiple stakeholders who have competing visions and requirements for success.

In addition to the five project domains listed above Browning and Ramasesh (2015: 56) identified the six factors driving uncertainty in the project, these factors can be used to justify spending more time in their detection:

- **Complexity:** Contains many interacting elements that increase the variety of its possible behaviours and results.
- **Complicatedness:** Regardless of its complexity, a system may appear more or less complicated depending on one’s point of view. In contrast to complexity, complicatedness is more subjective and observer-dependent.
- **Dynamism:** A project’s dynamism, its volatility or the propensity of its subsystems’ elements and relationships to change, adds to its complexity. A project’s external dynamics are especially likely to affect its goals.
- **Equivocality:** Project work requires a lot of sharing of information. If the information is not crisp and specific, then the people who receive it will be equivocal and won’t be able to make firm decisions. Although imprecise information itself can be a known unknown, equivocality increases both complexity and complicatedness.
- **Mindlessness:** We refer to the perceptive barriers that interfere with the recognition of unknown unknowns as mindlessness (as opposed to mindfulness). Examples include an overreliance on past experiences and traditions, the inability to detect weak signals and ignoring input that is inconvenient or unappealing.
- **Project Pathologies:** Whereas mindlessness pertains largely to the individuals associated with a project, project pathologies represent structural or behavioural conditions in and around projects as a whole that allow unknown unknowns to remain hidden.

Browning and Ramasesh (2015) discuss the presence of unknown unknowns, knowable unknown unknowns and known unknowns. The process they propose is to apply time and effort in converting the knowable unknown unknowns into known unknowns. From Browning and Ramasesh (2015: 59) ‘each of the six factors that increase the likelihood of a project encountering unknown unknowns can affect each of a project’s six domains, yielding 36 places to look more specifically for knowable unknown unknowns’. The authors provided the following 11 tools Ramasesh (2015: 59):

- **Decompose the project:** into subsystems to understand their structures, how their elements relate to one another and the sub-factors of complexity. This builds knowledge that helps expose unknown unknowns.
- **Analyse scenarios:** constructing several different future outlooks. This accepts uncertainty, tries to understand it and builds it into the reasoning.
- **Apply learning:** from past projects to future planning.
Scrutinise the plans: the plans should contain information about the expected work. These expectations need to be scrutinised closely by project participants and other stakeholders.

Use long interviews: with the project stakeholders, subject matter experts and other participants to uncover lurking problems and issues.

Pick up ‘weak signals’: such as unexplained behaviours, confusing outcomes or a realisation that no one in the organisation has a complete understanding of a project.

Mine data: electronic data mining can be a particularly powerful tool for extracting implicit, previously unknown and potentially useful information. Data mining could enable project managers to identify the precursors of potential problems.

Communicate frequently: along with reviewing the decision making, communication processes, including the assumptions that are factored into these processes. Seeking to remove information asymmetries to anticipate and uncover unknown unknowns.

Balance local autonomy and central control: Many unknown unknowns are obscured by the relationship complexity and dynamism of a project. As such this makes the project management team vulnerable to unwelcome surprises.

Cultivate an alert culture: that is made up of people who understand how unknown unknowns can derail projects.

Browning and Ramasesh (2015) promote the conversion of unknown unknowns by the application of the above principles described in their document and advocate the application of resources and time to this activity.

Examining the large project environment Dey (2009: 23) aim to develop an integrated framework for managing risks in large-scale construction projects. Dey (2009: 23) continues by stating ‘Conventional project risk management frameworks emphasise managing business risks and often ignore operational risks. There are instances of project failure because of operational risks (e.g., failure of project leadership, contractors' and suppliers' incapability, technical complexities etc.). A hierarchical approach deals with such shortcomings by analysing risks in different levels (e.g. project, work package and activity). It helps identify the least risky project alternative through project level risk analysis and subsequent work package and activity level risk analysis to help identify both business and operational risks’. Dey (2009: 23) states that ‘There are two approaches to construction risk management—project level risk analysis and work package level risk analysis, which are carried out during the feasibility analysis and implementation phases respectively. Both the approaches have limitations’. Dey (2009) proposes an alternative Risk Management Framework. ‘The proposed risk management framework has the following steps:

- Identifying the alternative projects,
- Analysing project level risks and selecting the least risky project,
- Developing the work breakdown structure of the selected project,
• Analysing work package level risks,
• Developing risk responses,
• Analysing activity level risks, and,
• Developing risk responses.'

Dey (2009: 26) ventures an analysis of project failures, ‘Construction projects often fail because of wrong technology selection, poor environmental management plan, political red tape, poor design specification, wrong implementation methods, poor performance of contractors, and lack of maintaining materials delivery schedule by the suppliers along with many other reasons’.

In summary Dey (2009: 26) states, ‘The causes of failure could be classified into business risks (external) and operational risks (internal). Unless they are addressed in the early project-planning phase and adequate responses are planned and implemented, projects inevitably fail to achieve their objectives’.

Hillson (2003: 85) examines using the risk breakdown structure in his paper examining the use of the risk breakdown structure in project management. Hillson (2003) carries the point of view that the structure of the risk in a project to enable areas of particular concern to be identified and addressed holistically. The traditional approach is to produce a long list of risks and to prioritise accordingly.

Hillson (2003: 85) states that it is necessary therefore to ‘indicate those areas of the project which require special attention, or expose recurring themes, concentrations of risk, or ‘hot-spots’ of risk exposure. The best way to deal with a large amount of data is to structure the information to aid comprehension.’ Further Hillson (2003) states that it is necessary to understand the nature of the project risks not just identify, list and categorise. Hillson (2003) proposes the RBS (risk breakdown structure) as the basis for risk understanding.

Hillson (2003: 87) states ‘Just as the WBS forms the basis for many aspects of the project management process, so the RBS can be used to structure and guide the risk management process. Some authors and practitioners have gone further in structuring risk than simply listing types of risk faced by a project. These have produced hierarchical structures under various names to describe sources of risk, or risk categories or types, though these are usually focused on a particular project type or application area.’

In the text Hillson (2003: 89) provides some guidelines as to a RBS in his paper and states that ‘Each of these RBS structures is different, reflecting the range of possible sources of risk exposure for projects in various sectors and industries. It is therefore necessary for any organisation wishing to use the RBS as an aid to its risk management to develop its own.’ Figure 3.3 below illustrates an elementary RBS structure.
Hillson (2003: 90) discusses the benefits of using the risk breakdown structure as being:

- Risk prompt list,
- Risk checklist,
- Ensuring complete risk identification,
- Assessing risk hot-spots,
- Providing additional assessment insights.

Hillson (2003: 94) includes the following table of benefits:

- Understanding the type of risk exposure on the project,
- Exposing the most significant sources of risk to the project,
- Revealing root causes of risk, via affinity analysis,
- Indicating areas of dependency or correlation between risks,
- Focusing risk response development on high-risk areas,
- Allowing generic responses to be developed for root causes or dependent groups of risks.

According to Hillson (2003) the risk breakdown structure can be used to support the tendering process, the evaluation of tenders and comparison of projects. In conclusion Hillson (2003: 95) states ‘The RBS is a powerful aid to risk identification, assessment and reporting, and the ability to roll-up or drill-down to the appropriate level provides new insights into overall risk exposure. A common language and terminology facilitates cross-project reporting and lessons learned.’
Kutsch (2008: 602) states, ‘Specific risk-related interventions strongly influence the effective use of project risk management: project managers tended to deny, avoid, ignore risks and to delay the management of risk. Risks were perceived as discomforting, not agreed upon. IT project managers were unaware of risks and considered them to be outside their scope of influence and preferred to let risks resolve themselves rather than proactively engaging with them. As a consequence, factors such as the lack of awareness of risks by IT project managers appeared to constrain the application of project risk management with the result that risk had an adverse influence on the outcome of IT projects’.

Is this phenomenon common place even outside the IT project management field? Certainly risks are not pleasant and require some effort to resolve. Is there a response that says that it is good to do nothing and let event take their course and allow the risks to resolve themselves? With the asymmetric information balance held by those proposing the project there could be a conceived desire to withhold risk based information to give greater assurance that the project will be supported and thus funded.

Following the survey Kutsch (2008: 602) identified the following: ‘Project managers encountered difficulties in managing project risk because of several risk-related interventions such as denial, characterised by anxiety among stakeholders due to the identification and analysis of risk. These interventions tended to influence project risk management in such a way that project managers overlooked risks that later materialised and resulted in an adverse effect on the project outcome’.

The primary objective is to deliver the project to scope, on time and on budget. A risk could be identified as being an event that affects the ability of the project manager to deliver on any one or combination of these aspects. Perhaps project managers are not addressing the risks optimally because of the perceived immediate effect on the project delivery, this is leading to the risks and risk management process not being optimally applied and a ‘come what may’ approach to managing the risks as they manifest themselves.

Following on and as a concluding article Raz, Shenar and Dvir (2002: 101) discuss the fact that though there is an extensive focus on risk management and performing risk assessments there is often little focus on the results and little focus on completing actions raised by the process. There is agreement that though risk management is a good thing the available risk management techniques are not widely used by organisations. Though there is a surfeit of tools and techniques many managers are reluctant to apply them to their project.

To Raz et al (2002: 108) there is possibly a lack of fundamental awareness and over optimism. There is enough literature stating that projects are risky ventures and the outcome is never certain, delay and failure is not the exception particularly in the large multidiscipline mining project environment. Confirming this Raz et al (2002: 108) state that projects suffer from unexpected outcomes such as delays, overruns and disappointing performance outcomes.
Project risk management is well covered in the contemporary project management texts. The key aspects developed here are the risks introduced by the project environment and the necessity to develop a risk management strategy relevant to the LMM Project. The traditional approach of using previously developed risk matrices could be inadequate for the LMM Project due to the complexity and uniqueness of these projects. The effect of the project complexity and uncertainty needs to be evaluated as a project risk along with the risks associated with assembling, developing and managing the project team. The physical size of the LMM Project has risk particularly regarding the funding risks and the logistical risks.

The literature discusses the use of the use of the risk breakdown structure to aid visibility and the necessity to ensure the risk management process is maintained and the risks identified are monitored and managed. There was a tendency to ignore risks and deal with them if they occurred in execution. Managing the project risks has to be part of the daily activity of managing the project and the project team has to be aware of the tendency for new risks to develop.

3.15 Project sponsorship

Project sponsor success is important to the success of the project. There are some fundamental differences between the roles of the client project sponsor and the EPCM Company project sponsor. Two articles were identified that discuss the project sponsor these are reviewed here.

Kloppenborg, Tesch and Manolis (2011) reviewed the role of the project sponsor and the behaviour required for successful project implementation during the project planning cycle. Kloppenborg et al (2011) identified five key behavioural factors of the executive project sponsor:

- Ensure planning,
- Clarify project outputs,
- Manage stakeholder relationships at the highest level,
- Support the project,
- Appoint a project manager.

These factors are discussed later in this section.

From Kloppenborg et al (2011: 414) client project sponsors are executives with an interest in the project success, charged with ensuring an effective project manager is in place their project managers and teams plan well, managing stakeholder relations, these actions are significantly and positively correlated with project success. These behaviours are a very good use of the executive sponsor’s limited time. As a counter point, sponsors personally handling details of clarifying project outputs are associated with reduced project success.
Clearly the authors recommend that the sponsor allocates time to ensuring the correct project manager is allocated to the project, that the team establishes the correct project communication structure and that the team plans well. The authors also identified that the project sponsor should not become personally involved in the execution of the project even at the early stage of the project.

Kloppenborg et al (2011: 404) reviewed the criteria for project success, they cite the following criteria as being the criteria for success:

- Success criteria should be determined and agreed with the stakeholders at times throughout the project.
- The sponsor and project manager should have a collaborative working relationship.
- Empowered to deal with unforeseen circumstances, the project manager should receive guidance from the project sponsor.
- The sponsor should take an interest in the performance of the project.

Kloppenborg et al (2011) for the purpose of their study identified the following sponsor key behaviours; ensure full planning, clarify outputs, develop stakeholder relationships, support the project, appoint the project manager. Kloppenborg et al (2011) during the course of their study expanded on the behaviour factors of the project sponsor this is shown in table 3.5 thus:

Table 3.5 - Sponsor behaviours, planning stage: derived from Kloppenborg et al (2011: 409)

<table>
<thead>
<tr>
<th>Ensure planning</th>
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<tbody>
<tr>
<td>Insist a communications plan is developed,</td>
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<tr>
<td>Ensure change control process is in place,</td>
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<tr>
<td>Ensure escalation process is established,</td>
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<tr>
<td>Encourage “small wins” to be built into project plan,</td>
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<tr>
<td>Hold periodic project reviews with project manager and team to address issues</td>
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<tr>
<td>of users/ customers,</td>
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<tr>
<td>Create communication expectations up front,</td>
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<tr>
<td>Establish standard chain of command,</td>
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<tr>
<td>Establish project priority,</td>
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<tr>
<td>Ensure project aligns with organisational objectives,</td>
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<tr>
<td>Help project manager understand the project business context,</td>
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<tr>
<td>Challenge project manager to consider more project options,</td>
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<tr>
<td>Validate project plan,</td>
</tr>
<tr>
<td>Provide leadership to define goals and assure agreement,</td>
</tr>
<tr>
<td>Help refine project purpose and objectives,</td>
</tr>
<tr>
<td>Validate project objectives,</td>
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<tr>
<td>Lead development of shared project vision and values,</td>
</tr>
<tr>
<td>Provide leadership to define deliverables.</td>
</tr>
<tr>
<td>Clarify outputs</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Clearly define constraints and goals,</td>
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<tr>
<td>Involve project manager in requirements gathering phase of project,</td>
</tr>
<tr>
<td>Develop clear picture of deliverables and primary objectives with sufficient</td>
</tr>
<tr>
<td>detail to avoid confusion,</td>
</tr>
<tr>
<td>Narrow scope and adjust objectives as necessary,</td>
</tr>
<tr>
<td>Drive out clarity on project needs and success factors.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Stakeholder relationship</th>
<th>Ensure customer is fully involved in planning and understands value of the project,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Develop relationships with peers in client organisation,</td>
</tr>
<tr>
<td></td>
<td>Demonstrate interest in project by devoting time and energy,</td>
</tr>
<tr>
<td></td>
<td>Ensure all stakeholders are identified,</td>
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<tr>
<td></td>
<td>Meet with client to seek understanding of client needs,</td>
</tr>
<tr>
<td></td>
<td>Meet with key individuals to reinforce project need.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support project</th>
<th>Seek additional funding to meet agreed upon scope, or reduce scope to meet budget,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Publicly support project,</td>
</tr>
<tr>
<td></td>
<td>Privately support project.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Appoint project manager</th>
<th>Hire outside contractor or consulting firm to act as project manager,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Replace project manager or arrange for a co-lead to fill the people skills gap.</td>
</tr>
</tbody>
</table>

Kloppenborg et al (2011: 412) discuss the project sponsor behaviour outcomes:

- **Meeting Agreements:** this is the only area where the project sponsor behaviour would significantly affect the project success, Kloppenborg et al (2011) generally better planning can be expected to achieve better results in terms of cost, schedule, and technical performance.

- **Customer Success:** in this area the sponsor is expected to attend to the high level activities and to leave the hands on activities to the project team under the guidance of the project manager. Project sponsor involvement in, for example the 'clarify output' function had a negative effect on customer successes. Kloppenborg et al (2011) the project sponsor should avoid constraining the project team and leave room in the project scope definition to allow for originality. In other words, the project sponsor should leave the project team to sort out the details with the client and allow latitude for innovative thinking.

- **Firm's Future:** in this area as with the function above the clarification of requirements is best delegated to the project team. In this area the best allocation of the project sponsors time is to the appropriate selection of the project manager and the review of the project manager’s performance and the oversight of the stakeholder’s relations. Stakeholder alignment is the process of identification of the key stakeholders, the identification of their needs and ensuring that their needs are prioritised.
At the initiation of the project the project sponsor must ensure the success of the project. The execution of the project has to be left to the project manager and project team with oversight from the project sponsor.

Helm and Remington (2005) evaluated the role of the executive sponsor in complex infrastructure projects. They state that from the outset the role of the project sponsor and the relationship between the project sponsor and project manager has not been studied sufficiently. According to Helm and Remington (2005) the project manager is compensating for ineffective project sponsorship, the project sponsor has an important role to play in the organisation and this is a role that the project manager cannot fulfil.

In the EPCM Company environment the challenges could be more significant where the project has a client sponsor and an EPCM Company sponsor.

Helm and Remington (2005) discuss the correlation between the role of the sponsor and the ultimate success of the project, and that little has been written about the characteristics of the project sponsor role. Helm and Remington (2005: 54) concurred with Kloppenborg et al (2011) and added the following beneficial attributes of the project sponsor:

- Appropriate seniority and power within the organisation,
- Political knowledge of the organisation and political awareness,
- Ability and willingness to make connections between project and organisation,
- Courage and willingness to battle with others in the organisation on behalf of the project,
- Ability to motivate the team to deliver the vision and provide ad hoc support to the project team,
- Willingness to partner with the project manager and project team,
- Excellent communication skills,
- Personally compatible with other key players,
- Ability and willingness to provide objectivity and challenge the project.

Helm and Remington (2005: 56) identified the tactics used by project managers to overcome inadequate project sponsorship. Though project may be deemed to be successful by the owner many project managers are managing projects in ways that might mask inadequate project sponsorship.

Helm and Remington (2005) intimated that often there was insufficient engagement by the project sponsor and a lack high level support to achieve the project goals they found a lack of project ownership by the project sponsor. Perhaps in the EPCM Company environment project sponsorship becomes more challenging particularly when there are many projects vying for resources and attention.
Helm and Remington (2005: 56) discuss the aspect of ‘tolerance for ambiguity’ they state that an interesting outcome of the study was the ability of the project manager and the project sponsor to handle ambiguity, this would be particularly relevant where the project is complex and ill defined. Helm and Remington (2005) identified from their study that there was a low tolerance for ambiguity reported by the group and that there was a necessity for the project manager to simplify and to a certain extent cover the project complexities. In the large multidiscipline mining project environment this would be particularly concerning as the projects are generally uncertain and complex with outcomes that have not been fully defined from the outset.

Helm and Remington (2005: 57) in conclusion state that the role of the project sponsor is vital to the success of the project. The role of the project sponsor is sufficiently complex and difficult, and the selection processes should be commensurate taking into consideration the nature of the project and its significance to the client.

Helm and Remington (2005) say that the project manager often is required to perform beyond the support of the project sponsor and this masks the poor performance of the project sponsor. In dealing with the project sponsor, information and concerns can become diluted and thus lack the strategic impact.

Obviously additional research would be required in this area particularly in the large multidiscipline mining project environment where there could be two levels of sponsorship, at the mining client level and at the EPCM Company level.

The fundamental characteristics of the project sponsor are corporate empowerment and networks, executive status and an interest in the success of the project. The project sponsor should ensure the project is planned and funded, the necessity for the project is clear, the major stakeholders are identified and the senior project managers are appointed. The fundamental differences between the roles of the client and EPCM project sponsors are to be explored further.

### 3.16 Communication

Following on from the role of the project sponsor where there is a necessity to engage with the project stakeholders comes the necessity to establish a robust project communication strategy.

Project are executed by people and the success of the project is governed by the ability of the people engaged on the project to work together as an effective coherent team. Effective communication is fundamental to the success of a large multidiscipline mining project as this ensure the team is fully integrated, involving the project team and engaging the stakeholders. The large number and the changing field of stakeholders require effective and specific communication strategies. There are a great number of articles covering this topic. The following three articles were identified in the literature search as being particularly relevant to this study.
Jacobsson (2009) reviewed the importance of communication for the instillation of good collaborative practices in the execution of the project. Jacobsson (2009: 64) describes in his paper where the, ‘focus is placed on illustrating the importance of the project liaison as a crucial part of the coordination of the project’. The author takes an esoteric view of communication and a series of liaisons and that these ‘guide and coordinates the ongoing activities, translates and reduces information, creates space for the experience of the subcontractors, assists in coordinating unexpected situations’, this highlights the importance of communication to project success.

Jacobsson (2009) reflects on the volume of published works that concentrate on the aspect of project communication. Communication becomes an aspect of coordination of effort between the various parties brought together by the project. In addition Jacobsson (2009: 65) discusses the need for effective coordination, ‘In the project setting these interdependencies mainly derive from the activities, the various groups, and the professions involved’. ‘Failing to coordinate activities in a suitable and effective way can have major negative consequences for the organisation, consequences such as confusion among participants, misunderstandings, increased costs, and in the worst case project failure’.

Jacobsson (2009) intimates that communication internally is a key aspect of coordination within the project team and home office environment, in the construction project environment this is an area of concern. This would be particularly relevant to the large multidiscipline mining project. For Jacobsson (2011: 67) ‘communication is important for the creation and maintenance of well-functioning links among different groups or units and that coordination and communication problems are likely to emerge in this kind of setting.’ ‘Linked to the extensive need for collaboration and the importance of inter-organisational relations, the construction process is almost exclusively organised in a project form’. ‘The temporary aspects of the projects are, moreover, shown to promote informal, spontaneous communication, and interpersonal coordination mechanisms that also nourish an extensive need for flexibility and teamwork.’

The uncertainty and complexity of the large multidiscipline mining project encourages the shift from the more formal communication strategies to the less formal and informal communication regimen.

Jacobsson (2011: 68) continues stating ‘as the coordination relies on communication and well-functioning diffusion of information throughout the project, the flow (or diffusion) therefore has to cross, be translated, or be bridged from the formal to the informal level and vice versa.’ ‘However, even with an understanding of the context, the central characteristics, and the built-in coordinative and communicative challenges of construction projects, the question of how these processes are linked together is still unanswered.’

Jacobsson (2011: 68) propose the role for the project liaison coordinator, ‘to serve as a communication crossroad that makes integration and coordination between different formal and
informal processes and the different knowledge domains easier.' 'The project liaison coordinator guides and facilitates the ongoing activities and creates space for the experience of the subcontractors'. 'Furthermore, the project liaison assists in coordinating uncertainty, unexpected situations, and arising problems'. 'A central part of the function of the project liaison coordinator is nevertheless the reduction and translation of information, activities that are found to be highly appreciated by the subcontractors.'

A significant challenge in the large multidiscipline mining project environment is the proliferation of asymmetric information. Schieg (2008) discusses the topic of asymmetric communication in construction project management. The author summarises thus, 'A construction project is characterised by a high number of project participants and a multitude of contract relations'. The asymmetric information distribution in projects can have a negative effect throughout the execution of the project. Therefore in construction project management attention has to be paid to where the imbalances occur. The imbalance is best managed and corrected as soon as it is noticed.

Schieg (2008: 48) describes asymmetric information as a situation in which one of the two cooperation partners is better informed than the other one. This can result in loss of benefit, economic disadvantage and the inefficient use of resources. There are obviously many areas where asymmetric information may proliferate one of these areas according to Schieg (2008) elaborates on is the selection of contractors, where the selection is based on what is declared by one and not declared by the other. According to Schieg (2008) a major success factor in the project management is to identify, those phases in which asymmetric information may affect the success of the project. The project organisation must be designed to identify those participants to be specifically managed to mitigate the effect of asymmetric information.

Schieg (2008) highlight the need for good information systems and transparency in information flows as a means for identifying and correcting information asymmetries. The advantages of the project communication system according to Schieg (2008) are:

- Transparency regarding responsibilities,
- Effective email communication to the responsible parties,
- 24 overview of the project status,
- Information can be recorded, processed and viewed at any time.

For Schieg (2008: 51) 'the more the communication within the project is structured, the easier it is to prevent information asymmetries.'

Critical to the success of the project is ensuring the client is aware at all times what is going to be delivered, when and at what cost. In the execution of a large multidiscipline mining project gaps can develop between the activities of the EPCM Company and the perceptions and expectations of the client. This is addressed by Bourne (2011) giving a framework for the engagement of senior
management stakeholders. This is an aspect directly involved in the management of perceptions and the closing of an aspect in the gap between what is expected and what is to be delivered.

Bourne (2011) tables the stakeholder circle methodology in figure 3.4 below and highlights the five well known stakeholder management steps:

- Identify all stakeholders and document their expectations,
- Prioritise,
- Map the current stakeholder community, showing each stakeholder’s relative importance, power and influence,
- Engage through understanding each stakeholder’s attitude to the activity and develop targeted communication,
- Monitor the effectiveness of this communication.

The stakeholder circle methodology is illustrated below:

Figure 3.4 Directions of stakeholder influence: from Bourne (2011: 1005)

Bourne (2011: 1008) discusses the transition strategies for the new executive’s success:

- Managing upwards through clarifying expectations of key stakeholders on objectives, goals and leadership styles,
- Building alliances and support structures through establishing personal credibility with stakeholders and understanding the culture (of the organisation, but also of the leadership team – the peers of the executive),
- Focus on personal reinvention – substituting skills, values and behaviours not appropriate to the new role with those that were now appropriate.

Bourne (2011: 1010) reflects on the communication challenges of the matrix organisation that typifies the EPCM Company structure particularly when the large multidiscipline mining project.

- Multiple/ competing lines of authority,
- Virtual and partial/ part time teams,
• Changing scope and divergent objectives,
• Many levels and types of authority.

Bourne (2011: 1010) states ‘Matrix organisations require multiple relationships. In a matrix organisation, successful delivery will be complicated by multiple reporting relationships for team members and consequent issues around acquisition and allocation of resources from multiple sources as well as the complexities of communication to multiple managers.’

Bourne (2011: 1013) highlights the need for balance regarding the engagement of stakeholders, ‘Focus on one stakeholder can lead to neglect of other equally important but less vocal stakeholders, leading to their perception of failure of the work because it had not delivered to their expectations or requirements.’ For Bourne (2011: 1013) ‘Without a clear understanding of the stakeholder community of this project: who all the stakeholders were, who was most important at that time in the project, what the expectations of all these important stakeholders were, and their level of support, it would be impossible to know how to engage stakeholders for success.’

As seen before the stakeholder community will change during the execution of the project, the project will move from one phase to another and, particularly in the execution of a large multidiscipline mining project different stakeholders from the client, contractor and EPCM community will change.

In conclusion Bourne (2011: 1019) describes the technique thus, ‘The techniques for managing the expectations of senior stakeholders and managing the behaviours of difficult colleagues used by the managers appear to be instinctive. In reality the approaches were probably partly instinctive and partly developed from experiences from a variety of sources, both business and personal’. ‘This paper defined a framework to assist individuals in an organisation to build relationships with senior stakeholders through building credibility so that when support is needed, it is readily given’. The author’s guidelines recognise the need to understand and manage the expectations of the stakeholders, and to build and maintain relationships within and around the individual’s area of influence. These guidelines are the same for anyone in an organisation who needs to engage their own senior stakeholders. The two case studies described situations often encountered in organisations. It is important recognise that the perspective of the stakeholders comes from their own background, experiences and the organisational culture.

Communication has been widely covered in project and management literature and is one of the priorities of the project management team. The managing of stakeholder perceptions is of fundamental importance to the success of a project. Success can be seen as meeting the requirements of the client and the requirements can be viewed as being the definition of the client’s perception of what the project has been defined to be. The environment of the LMM Project has changed; both becoming more international in resourcing and in the building of virtual project
teams. This has placed greater emphasis on the project communication and the development of specific communication strategies that will cover the international project team.

3.17 Project close out

The LMM Project will get to the point where close out has to be effected. During the execution of the project certain work packages will be closed and handed over use by the contractors or by the client.

Often LMM Projects are subject to changes that are imposed upon the project after the project has been closed out by the EPCM Company and after the completed project has been transferred to the client for operation. One article was identified covering this topic.

Andersen, Olsson, Onsøyen and Spjelkavik (2011: 308) examine the volume and background of changes done shortly after project completion. The study indicates a need for new performance measures for projects, as the current parameters motivate project managers and their teams to focus on project cost and timely delivery, rather than life-cycle cost.

The authors conducted a unique study, most previous studies had concentrated on the changes and change management during the execution of the project but there was not too much material on post project completion changes. Post project changes are, for large multidiscipline mining project when the completed project is made operationally suitable with activities after the project has been apparently handed over.

Andersen et al (2011) cite some examples from Australian construction projects where the primary source of changes to the completed project were at the discretion of the client and also from errors or omissions in the contract documentation. Andersen et al (2011: 310) found that client-initiated changes and ineffective use of information technology by the designers, as well as creation and management of contracts were significant in contributing to post completion changes. They also found that early freezing of the design scope also contributed to rework, especially for less experienced clients.

Design scope freezes, though attractive for expediting should only be affected when all of the design input information can be assured to be complete and final. Certainly in previous discussions the design freeze is a valuable tool for meeting the contract deliverables and for preventing too many iterations in the design process.

Andersen et al (2011: 310) state that the mean cost of rework is 6.4 and 5.6 percent for direct and indirect costs giving a total rework cost of 12 percent. Andresen et al (2011: 310) identify five groups of changes:

- Operational changes affecting the function of the project deliverables,
• Changes for improvement of safety, for personnel and equipment,
• Aesthetical changes for comfort or visual considerations,
• Uncontrollable changes, e.g. alterations due to changed regulations,
• Financially motivated changes, aiming at improving the profitability of the project.

Andersen et al (2011) cite authors who state that one of the major weaknesses in project management literature is the notion that the entire scope of the project can be known up front. This is particularly apparent in large multidiscipline mining projects where the scope can be uncertain and there can be significant scope changes during the execution of the project. Andersen et al (2011: 311) state that changes during a project are mostly viewed as negative and undesired in project literature, as they cause negative effects. Many authors discuss that as soon as a project has been sanctioned and execution has commenced, scope changes are likely to reduce the project performance, and often cause cost overruns. Change control is therefore aimed at either barring changes or handling essential changes in a controlled manner.

Andersen et al (2011) confirm the negative effect of changes:

• Increased costs,
• Delays,
• Reduced team morale,
• Reduced team productivity,
• Tension amongst the stakeholders.

Andersen et al (2011) recall in their text the fundamental challenges facing project delivery, ‘Owners and users will focus on organisational needs while the contractor will focus on the technical aspects of the delivery’. Scope changes can be proposed because client’s have new needs. The reduction in project performance due to a change might be balanced by an increased value of the project seen from the client perspective. From the study Andersen et al (2011) discovered that 48.3 percent of the projects reviewed had seen some post project changes in the first two years after the completion of the project. Andersen et al (2011) presented the following table 3.6 of post project changes for review, road and rail project were least subject to post project changes, it would be of interest to have the same study on more complex projects:
Table 3.6 - Frequency of post project changes: derived from Andersen et al (2011: 314)

<table>
<thead>
<tr>
<th>Post-project changes occurred?</th>
<th>Yes</th>
<th>No</th>
<th>Do not know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Road</td>
<td>7</td>
<td>12</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Building</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>14</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Percent</td>
<td>48.3</td>
<td>48.3</td>
<td>3.4</td>
<td>100</td>
</tr>
</tbody>
</table>

The study of Andersen et al (2011) also concluded that changes made during the project execution were not as expensive as changes made after project completion. This would be fairly obvious as the tendering process would have to be re-run, and a contractor would be required to establish site and mobilise plant. This would also be apparent in the LMM project, the mining facility has been handed over for production and any post project changes would impact on the client’s beneficial use of the facility, hindering access and revenues.

Andersen et al (2011: 317) identified the main causes of post project changes:

- Aspects overlooked during engineering: 41 percent
- Users not aware of the need: 23 percent
- New user demands: 14 percent
- Changed external conditions: 14 percent
- Changed operational conditions: 5 percent
- Rationalisation of operations: 5 percent

Andersen et al (2011: 318) asked for opinions from project managers on the effective countermeasure for post project changes:

- Better engineering: 33 percent
- Better operational involvement: 25 percent
- Better user involvement: 16 percent
- Identify future changes in external conditions: 14 percent
- Flexible execution model: 10 percent
- Flexible design: 3 percent

There was a similar distribution with the opinions from operational staff at the facility.

Andersen et al (2011) discussed the impact of the post project activities and changes and concluded in the main that the impact of the changes in the environment reviewed were not
significant and that the client had utilisation of the completed sections of the project. These would transfer well into the large project environment in so far as there is a significant degree of uncertainty at the outset of the project and during the execution phase there could be a significant development in the user requirements.

To the lists above Andersen et al (2011: 320) added the following change criteria:

- An altered strategy of use for the deliverables,
- Client management changes,
- Environmental issues or safety issues for operation personnel,
- Requirements not identified due to lacking abilities of users in explaining what they want or understanding drawings showing solutions,
- Budget cuts and under dimensioning, often as a result of early, low estimates being perceived as precise and final,
- Technical equipment does not work as intended,
- The operational organisation does not have the capacity/ people to participate properly in the engineering,
- The operational organisation makes proposals for solutions, but fails to have these accepted.

During the study the authors also reviewed the projects that were subjected to project budget cuts and identified that these projects also experienced the highest degree of post project revisions and changes. These changes were often to restore functionality where this had been removed due to these cuts. This would indicate a need for communication and discussion on a multifunctional level with the client project and operational personnel.

During the execution of a large multidiscipline mining project there is often pressure to cut the scope of work to save on costs, often this means that the full facility is not completed and remaining scope will only be completed in the operational life of the mine. Clearly the leading factor is greater involvement of the client company operational personnel to ensure there are no surprises when the completed project is handed over and that the client has been fully involved in the evolution of the project and understands fully the constraints and engineering concerns of the EPCM Company.

In conclusion Andersen et al (2011) identify that many of the projects reviewed are subject to post project changes. The degree and impact of these changes is dependent on the nature of the project being undertaken and the degree to which the project can be clearly defined and documented at the outset. There were several categories of project that were less susceptible to post project changes and certain categories that would be more significantly subject to post project changes.
The project team is often not the final custodians of the completed project, some contracting model will make the project team run the plant for a period of time after the project completion however. Following the commissioning of the project there could be a performance guarantee requirement but often as we have seen there will be a period where the completed project is subject to modification to suit operational requirements. There are lessons to be learnt from the literature that can mitigate the necessity for post project changes.

There would be scope to generate a similar study in the large multidiscipline mining project environment and projects executed in the mineral processing industry. The results should be similar to those identified by Andersen et al in 2011.

3.18 Conclusion

In this chapter the review of the current literature covered the project management aspects that reflect on the relationship between the EPCM Company and the Client.

From the literature review in chapters 2 and 3 a series of questions are developed in chapter 5 to test the level of understanding within the EPCM Company environment.

In the following chapter 4 the mining literature is reviewed for cases relevant to the environment of mining project execution.

Chapter 4: Mining industry periodicals review

4.1 Introduction

Chapter four has been written to give context to the study with regard to the execution of large multidiscipline projects in the mining industry, in particular the mining industry in the international environment.

The mining periodicals that were reviewed highlight key aspects that have been summarised under the following four headings:

- Complexity and uncertainty,
- International aspects,
- Rescheduling, execution delays and expediting,
- Budget cuts and capital re-scheduling.

The EPCM Company executing a large multidiscipline mining project can expect the project in execution to be subject to some if not all of these aspects
4.2 Mining industry periodicals review

4.2.1 Complexity and uncertainty

The global mining industry is subject to project complexity and execution uncertainty as highlighted in the articles presented below.

Hinde and Ericsson (2013: 3) write that in at least two aspects gold mining stands separate from other parts of the industry. The price of gold tends to move in the opposite direction to other base metal commodities. Gold tends to behave more like works of art and property, gold tends to be considered more like a store of wealth. Continuing Hinde and Ericsson (2013: 4) state that there are vast stocks of previously mined gold so supply is rarely a problem, with this as a backdrop gold has lost much of its appeal as a store of wealth.

Hinde and Ericsson (2013: 5) reflect further on the plight of the gold mining industry in that the producers have suffered from rising operating costs where they are encouraged to mine the lower grade ores as the value of gold has been increasing. Frequently the gold mine has a secondary product such as copper. In 2013 this product was subject to a reduction in value.

Hinde and Ericsson (2013: 6) conclude with a view of the gold outlook, they reflect on the aspect that the gold price will reach a point where the revenues have to sustain the mining community as a point where the commodity price makes the lower grade ore bodies unprofitable would not be sustainable.

Continuing with gold Hambro (2013: 12) reflects on the ‘Changing Strategies in the Gold Mining’ industry. Hambro (2013: 13) states ‘although the recent gold price moves have caused the miners to change strategies simply to survive, investors have been crying for better cost discipline and higher returns for many years now’. In addition Hambro (2013: 13) discusses the lack of cost discipline on behalf of the producers; the average capital expenditure per tonne was exceeding the value of the product for the seven years up to 2013.

Hambro (2013: 13) poses the point that the mining CEO’s seem to have lost their direction during the period of gold price appreciation, growth plans were expedited and mergers and acquisitions were the rage. The high demand for capital items caused costs to rise with the fall in returns and investor’s confidence to fall. The end result of this period was cost cutting. Hambro (2013: 15) discusses some of the projects that were delayed including BHP Billiton’s Olympic Dam project as part of a corporate cost cutting drive.

Continuing with cost cutting Anon (2013e1: 3) in an article titled ‘Barrick downsizes amid gold price fall’ reflects on the downsizing that was common place during the continued fall in the value of gold. There were widespread job cuts in the office of Barrick in an effort to manage the overhead costs of the company. This was in parallel to the fall in the share price of the company; the NYSE price of the share had fallen by 57%.
Continuing this discussion Treadgold (2014: 14) debates the prospects for gold in the international market, he asks ‘where next?’; ‘Changes in the global economy will continue to bear down on gold after the current bout of excitement settles’. ‘The return of the US, however, is what will cause gold its greatest problem because a stronger US economy means a stronger US dollar’. ‘It will be extremely difficult for gold, as measured in US dollars, to continue rising whereas gold, as measured in other currencies, will start to look more appealing.’ ‘As markets adjust, normal service will be resumed. Gold will slip lower and industrial metals will settle around current levels, with the big change for miners being the benefit of selling commodities in US dollars off a cost base in a deprecating local currency.’ ‘Among the economies likely to suffer a bout of capital flight, the big one could be Russia with a run on the rouble a possibility after the winter Olympics in Sochi.’

In the past few years the greatest area of change in the mining industry has been in the development of software applications that are specific to the mining industry. According to Anon (2013t1: 36) ‘at each stage the professional now expects appropriate computer software and hardware to be at hand’. Anon (2013t1: 36) states that ‘the past ten years has outstanding technological advancements in mineral exploration data collection, interpretation and modelling, and as a result mining and exploration software continues to achieve greater industry acceptance and adoption’. This form part of the digital revolution and in 2012 the following trends were identified; the cloud, a service centric approach, business process integration to create synergy, distributed computing. Similar software revolutions are taking place in the EPCM environment in both daily operations and in the integration of large multinational companies.

As we will see in other articles Russia holds huge resources and huge potential for mining companies. According to Walker (2013: 18) Russia has an estimated 15 to 17% of the world’s mineral resources and a similar share of the global mineral output and at that time Russia was a global leader in the production of gold, diamonds, nickel, copper, iron and platinum.

No review of the mining industry would be complete in any circumstance without including an article concerned with the safety of the miners in terms of direct and indirect safety and health. Anon (2013I: 1) discusses a settlement of Anglo American with regard to silicosis. ‘Anglo American plc has settled a compensation claim in a silicosis case brought by former miners.’ This was a first for South Africa; the case according to the author involved 23 miners employed on the company’s Free State mines. Interestingly the case involves cases of silicosis and silicotuberculosis contracted by the miners on Anglo American Mines as a result of the company’s failure to take necessary precautions to control dust.

As discussed elsewhere local and national mining legislation can present serious challenges to mining companies, at a national level the country has to present transparent and manageable legislation to attract foreign investment and to ensure fairness and sustainability to locals and national government. Rhodes (2013: 17) discusses Brazil’s regulatory reform, ‘mining is a key Brazilian industry, with annual production worth USD42 billion. Iron ore alone contributes 85% of
mineral export revenues making Brazil the world's second largest iron ore exporter'. Delays and uncertainty in the regulatory reform has directly affected the investment in mining exploration, only three concessions were granted in 2011 leaving 120 unresolved.

In 2011 there was a significant seismic event in Japan that had a significant effect on the uranium market, in less than a week the market price of uranium fell by 25% as a direct result of the negative sentiment generated by the consequential damage caused on the Fukushima power station. Many nuclear fuel plants were either shut down or projects were cancelled. According to Hinde (2011: 1) there are 438 new nuclear reactors around the world, 310 are being proposed, 158 have been funded and are in planning, 62 are under construction. According to Hinde (2011: 1) the nuclear power industry is volatile and fickle, nuclear accidents at Three Mile Island and Chernobyl have each brought project to a halt or have cancelled projects in planning.

Thus supposedly unrelated events can have a direct effect if delayed effect on the mining industry. In 2014 according to Gleeson (2014: 18) the Fukushima disaster resulting from a Tsunami flooding basement pumps in a nuclear power station had a catastrophic effect on the price of Uranium. From 2007 to 2014 the price of Uranium fell 75% as nations took the opportunity to review power generation plans, Germany sought to close marginal plants and shelved plans for new stations, Japan followed a similar course of action until the generation void proved to challenging to bridge in the short term.

Anon (2013m2: 8) in an article titled ‘More cost cuts by Paladin after Uranium price fall’ reflects further on the industry crisis following the big if temporary switch from uranium to other fuel sources. Anon (2013m2.8) discusses the USD23 million in capital expenditure cuts and that Paladin was to suspend all activity on exploration projects in Canada and in Australia. Paladin was also in the process of selling off interest in some of their mining assets. According to Gleeson (2014: 18) though the yellow cake market has been affected the more vociferous states have pledged to curtail the production of greenhouse gasses.

Complexity in mining activities can seldom be more pronounced than in sea bed mining. From Anon (2013c2: 7) UK Seabed Resources received a license to explore an area of 58000km² for mineral rich polymetallic; tennis ball sized nodules that contain copper, nickel, cobalt and manganese as well as other rare earths, nodules. Preceding any harvesting of these nodules would be an extensive environmental survey and a thorough examination of the seabed ecosystem. From Anon (2013c2: 7) the race is on and other countries such as China, Japan, Korea, Germany, Tonga and Russia hold licenses in the Clarion Clipperton Zone.

In a situation that is becoming all too familiar in South Africa Anon (2013m1: 6) in an article titled ‘Tenke Fungurume operations hit by power outages’ writes about the power outages on a mining project in the DRC. The state owned power company SNEL was being engaged by the mining company in an effort to resolve the energy situation. According to Anon (2013m1: 6) Tenke Fungurume had made substantial investments in SNEL to secure the power supply to the project.
but had lost substantial product from the mining operations. Other mining operations in the DRC were similarly affected by the electricity predicament in the country. According to Anon (2013m1: 6) SNEL were in the process of refurbishing two 225MW hydro turbines at the Inga dam with a view to restoring power supplies.

Treadgold (2013: 12) discusses some of the regional predicaments that the mining industry is facing. The article is titled ‘High noon at Rio’, Treadgold (2013: 12) writes ‘here is a question that many executives would prefer to brush under the carpet, why have the world’s major mining companies written off more than USD50 billion in failed investments in the last few years?’ Treadgold (2013: 12) speculates that basically many of the senior managers in the mining industry are just bad at their jobs. Treadgold (2013: 12) quotes a few cases that have quite high numbers in terms of the losses accrued, a Rio Tinto 70% write down of an acquisition for USD38 billion. Rio also had to cut USD3 billion off the value of a Mozambique coal asset – this drove the write down tally to USD28 billion. As Treadgold (2013: 12) states, reports of asset failures and write downs are quite rare as people prefer to hear good news but the common thread is most of these failures can be written down as excessive executive hubris.

One of the other key contributors to this running uncontrolled is the phenomenon is ‘group think’, from Treadgold (2013: 12) group think is where all the participants are expected to agree and prefer to keep quiet rather than be branded as a non-cooperative outcast. Treadgold (2013: 12) continues, ‘whatever the reason is for there being so many slipups at the mining majors, the fact remains that the sector has been an enormous disappointment for investors, especially when compared to the performance of other industries’. ‘Little wonder that when the mining companies raise capital they invariably pay a premium above the rest of the market because of the perceived risk and their record of destroying, not creating, shareholder wealth.’

These articles demonstrate the volatile nature of the mining industry, an industry that sits at the starting point of a long chain of industries and consumers. A tsunami resulting in damage to a nuclear power station results in a collapse in the world Uranium price.

Following natural disasters local legislation can create uncertainty in the mining industry, local government can do much to smooth the path for the investors but in the end investment will be encouraged by a sympathetic application of mining legislation. Eventually however some of the issues from the past may surface, and in heritage occupational health issues, and require reconciliation.

Obviously project complexity and uncertainty is prevalent in LMM Projects. Some of the uncertainty comes from the geological aspects of the project and some from the remoteness and hostility of the project location. Significant funding is required for the project and the fortunes of the financing organisation can affect the flow of funding into the project. Funding can also be affected by the future valuation of the commodity.
4.2.2 International aspects

Mining projects are geared to the economic availability of the resources and as the easy to win resources are mined out so the exploration has to venture further afield. The mining companies have to cross over international boundaries and into the more inhospitable areas in the search for mineable resources. The exploitation of the resources can bring wealth and development to countries, and if well managed will leave a legacy of infrastructure development, technology enhancements and skilled engineers and artisans.

On the other side complex mining legislation applied inconsistently can serve to erect barriers to mining development and result in investment being channelled to more amenable administrations.

The mining industry has the ability to drive development in nations and make significant contributions to gross domestic products.

4.2.2.1 Mining in Mongolia

According to Anon (2012e1: 4) ‘in 2011 Mongolia was the fastest growing economy in the World’. As they state ‘once Rio Tinto’s Oyu Tolgoi comes into production Mongolia will become a major global exporter of copper and gold’. At that time the prediction was that Mongolia will become one of the three top locations supplying the global demand for these commodities. The mining industry has therefore the ability to change nations. According to Anon (2012e1: 5) there are vast areas of this remote country that houses vast resources of copper and gold. Anon (2012e1: 5) discusses some of the tribulations of working in this area, in the election run up there was a focus on the corruption in the issuing of the mining concession to foreign owned companies. Though there was no change in the acceptance of Foreign Direct Investment the government was striving for a greater share of the wealth created for Mongolian citizens.

Anon (2013e1: 6) discusses the Mongolian reforms cover such aspects as government funded exploration, transparency in license issuing, review of strategic deposits, value adding to raw materials and a review of the double taxation treaties. Anon (2013e2: 8) reflects on the ownership stake by the Mongolian state in the Oyu Tolgoi mining prospect. Initially this was 34% but the Mongolian Government wanted to increase this to 50%. This decision sent shock waves through the investment community. Anon (2013e2: 9) states that there is a trend for more state involvement in the mining industry in Mongolia. This was expected to influence the tendering process in terms of mine ownership and to affect the appointment of service providers. The International companies have to be part of the process as they bring necessary skills and equipment; there would certainly be a strong drive to have a residual learning remaining in Mongolia. Oyu Tolgoi in Mongolia would seldom be far from the news headlines as Mongolian government fought for a greater share of the revenues that would be earned by this prime copper asset and negotiated for a greater retention of skills in Mongolia after the project teams had been dispersed.

Anon (2013o1: 3) stated that for Uranium resources in the country being examined by a French firm called Areva would hold a 66% stake in the mining LLC and the Mongolian government...
through Mon-Atom would hold the balance of 34%. The Mongolian government was at that time encouraging foreign investment following a tail off in the following year. Areva was the main driving company for the exploration of Uranium assets in the country. According to Anon (2013o1: 3) Rio Tinto was at that time busy opening up the Oyu Tolgoi copper and gold mining prospect and the USD1 billion in underground development had stalled.

Moving west from Mongolia of all counties Turkey has a rich history of mining with some areas having been exploited for mineral resources for over 9000 years. This is discussed by Anon (2011c1: 2), Turkey is said to contain 3% of the world’s achievable mineral resources including rich resources of borax, bentonite and perlite. Valuable as these resources are the untapped gold resources are proving to be particularly attractive to investors.

4.2.2.2 Mining in Russia

Moving north, in a review of Russia and the eastern state of Irkutsk. Anon (2012b1: 2) discusses the influence of the Cossacks on the region and the gradually increasing influence of Russia on the region as a route to the Pacific. The region has traditionally relied on the natural products of the area but this has been gradually overtaken by the resources of natural gas, iron, coal, gold, silver, lead and zinc. According to Anon (2012b1: 2) the region contributes 5% of Russia’s GDP. Anon (2012b1: 2) says that exploitation of the natural resources is causing environmental deterioration and over half of the population lives in poverty. Clearly the sympathetic development of the mining industry in this area with carefully and fairly administered mining legislation is what is required to uplift the infrastructure and the local population.

Anon (2012b2: 4) the Far Eastern District of Russia has a clear focus on the rich mineral resources of this region. In 2012 the mining industry had the potential of contributing 37% to the economy of the region. Exploration is critical to mineral resource development and in 2010 there were 580 exploration projects of which 486 were for hard minerals and the balance for hydrocarbons or on ground water. From Anon (2012b2: 6) the area has significant Platinum Group Mineral deposits, high grade silver deposits and two large gold deposits. This would certainly be enough to attract significant foreign investment. This would contribute to sustaining Russia’s leading position as a leading world gold producer.

Anon (2012b3: 10) looks at the activities of Kinross as a foreign investor in the Russian mining industry. As a Canadian Investor they have been active in the region since 1995 and is the largest foreign in the Russian gold mining industry with over USD2.2 billion invested in the region. Anon (2012b3: 11) have identified the following aspects for success; establish a long term strategy, develop high quality assets, hire locally, use high technical and environmental standards, all level partnering with stakeholders, use the best technologies and equipment, manage the logistics effectively and a full commitment to corporate responsibility. These are certainly applicable to all such ventures.
The Far East of Russia is certainly remote, from Goryachev and Galtseva (2012: 12) the resources of the remote Magadan region are a significant contribution to the local economy. This is a famous gold mining region and the exploitation of the mineral resources has contributed to the regional economy for the past 80 years. Historically the region has contributed 25 to 50% of the gold production of Russia this is no longer the case for this remote region. Goryachev and Galtseva (2012: 12) state that the traditional alluvial resources have been depleted and exploration has revealed rich resources of other mineral resources.

Goryachev and Galtseva (2012: 12) that the region has proven resources of 21000 tons of silver, other metals include zinc, lead, tin, tungsten, copper and molybdenum. In the more logistically remote areas there are proven reserves of 1000 Mt of iron ore, the remote location of these resources make exploitation currently challenging. Goryachev and Galtseva (2012: 12) describe the inferred resources of coal for the region as being 43000 Mt.

The exploitation of the mineral resources can present additional complications, in the Kyrgyz Republic, Anon (2013w1: 14), the mining industry is dominated by complex geology. The geology of the Kyrgyz Republic is dominated by the complex structures that rise from the Tien Shan mountain belt. The complex geology of the region is the home of mineral resources such as iron, vanadium, copper, tungsten, gold, silver, beryllium and so on.

4.2.2.3 Mining in Canada

Though Canada is recognised as being a favoured investment destination unusually according to Singleton (2014: 15) British Columbia (BC), Canada’s second-biggest mining state could be facing ongoing cost pressures as the battle for labour continues. According to Singleton (2014: 15) ‘the western province of BC ranks second in Canada, with an overall value of production of CD8.3 billion, BC is Canada’s largest producer of copper, the largest producer of coal and only producer of molybdenum. The industry is however under pressure due mainly to falling coal and copper prices. From Singleton (2014: 15) the mining companies are seeing increasing production costs not least of which is the increasing cost of labour. The BC mining industry employs 10419 people which had risen from 9310 in the previous year the average annual salary rising from CD115700 to CD121000. The Canadian mining industry is facing labour shortages as expansion continues, this is hoped to addressed by attracting more locals into the industry and creating opportunities for women and immigrants. From Singleton (2014: 16) BC faces investor reluctance due to imprecise local legislation that has made land ownership contentious and unclear; land use uncertainty has also acted as a deterrent to investment.

Singleton (2014: 18) also looks at the mining prospects in Alberta, Canada. The relentless quest for oil and the resources of oil-sands in Alberta almost doubled the number of licenses being granted for this area. The quest for exploitation of the oil-sands has almost caused the oil and gas sector exploration to come to a complete standstill. For Singleton (2014: 18) the state of Alberta
collects CD4.5 billion from the oil sands exploitation, and the proven oil reserves from all sources places Alberta third in the world ranking after Venezuela and Saudi Arabia.

### 4.2.2.4 Mining in Brazil

Brazil is a vast country with similarly vast mineral resources, Anon (2013v1: 2) discussing the potential benefits of exploring mining resources in Brazil states that the area is rich in polymetallic resources of close to 3000Mt with vast unexplored areas. The mineral production in 2010 equalled USD40 billion. In Brazil close to USD300 million is spent annually in exploration but even before the exploration takes place the developers are reviewing the cost of setting up an operational mine in the light of the royalty charges imposed by the State.

Anon (2013v1: 2) indicates that bureaucracy in Brazil is a significant challenge and the State was setting up New Mining legislation. In Brazil currently mining is not a significant contributor to the GDP as it would appear to be in other South American countries. Environmental concerns are challenging for any mining operation and in Brazil these challenges are further compounded by the extremely slow licensing process. Anon (2013v1: 5) however regards Brazil to be an attractive proposition to mining companies because it is stable and there are huge deposits either to be exploited or to be found. This would of course present challenges in terms of logistical support and the provision of basic services.

Anon (2013v2: 11) discusses the stalled mining titles issue ‘the other key concern is the impact of the delays around the mining code on investment confidence’. Significant investment is being held up over concern from the delays in issuing tenure title. New legislation is required but no one is certain when this will be put before congress and this is slowing or has slowed the issue of titles.

### 4.2.2.5 Mining in Greenland

The environmental damage caused by global warming has opened up areas for exploration that were previously inaccessible.

As the quest for minerals become more and more challenged and areas previously not considered become more and more economically viable so areas like Greenland become exploitable. Greenland has only become viable as global warming has started to open up areas for exploration. Pieterse (2013: 15) discusses the prospects for Greenland, ‘Greenland is a self-governing territory belonging to Denmark, the population of 57000 contributes to the least populated country in the world.’ Continuing Pieterse (2013: 15) states that the revenues from the mineral resources could fund financial independence from Denmark and the rest of Europe.

Nuthall (2014: 1) writes in an article titled ‘Greenland’s new leaders may raise mining royalties’ that ‘mining companies may have to negotiate harder and pay more to secure mining concessions in mineral rich Greenland after the opposition won the autonomous territories general election in March 2013. According to Nuthall the ruling party is less supportive of foreign mining interests than the outgoing party. After a brief period of exploration and development the new legislation will certainly require the payment of increased royalties and apply new labour legislation impeding
the unrestricted use of cheaper foreign labour. According to Nuthall (2014: 1) the focus on Greenland and self-determination will push the government to develop a Greenlandic economy and the exploitation of the mineral resources will be instrumental in funding and developing this economy.

The Greenland mineral resource company North American Nickel according to Tredway (2013: 6) was making good progress in the exploration of the area for mineral resources. North American Nickel was using the latest technologies and drill to quantify the mineral resources in areas known as Imiak Hill and Spotty Hill.

4.2.2.6 Mining in Africa

In the African continent there has been significant renewed interest in the redevelopment of copper mining. Part of this renewed interest has been the investment in the Zambian Konkola copper mine. In a recent visit by an EU Delegation according to Anon (2012c2: 11) there was significant interest in the application of new technologies and in the important socio-economic development of the region. Modern mining methods are key to the development of the region and the structured investment into education, health and sustainable livelihoods will develop and leave a lasting legacy.

The troubles in the South African mining industry that we have seen in the past few years have had a significant effect on investor’s confidence. Treadgold (2013: 12) reflects on the South African exodus of one of the stalwarts of the South African mining giants Gold Fields. Treadgold (2013: 12) raises the following points ‘Gold Fields operates mines in Western Australia, Gold fields has changed its name in marketing material to The New Gold Fields, Anglo American started the trend away from investment in South Africa long before Gold Fields, Gold Fields and Anglo American have started a planned relocation of investments and the human resource’. These two companies dominated the gold mining industry in South Africa for many years and now are engaged in a planned capital flight strategy.

4.2.2.7 Mining legislation

Regional mining legislation and the implementation of this legislation has by far the biggest effect on the development of the mining industry in that region the following articles. The mining legislation can either stifle development or encourage development. On the other side of legislation are the proliferation of corrupt practices with will also have a negative effect on capital investment, particularly from investors with a profound social conscience.

Koneska (2013: 16) reviews the Central and Eastern Europe mining legislation and the readiness for this area for accepting and encouraging mineral exploration and mining activities. Koneska (2013: 16) recalls the previous regimes in the region when it was dominated by Russia. With the collapse of Soviet control in 1989 the mining of this region fell into neglect, the application of new mining legislation has been designed to encourage the exploration and the mining of the region.
Koneska (2013: 16) states that most states in the region have or are becoming members of the EU which will bring with it a steady harmonisation of the mining legislation with the EU standards this will bring with it greater confidence in the investors with respect to regulatory uncertainty.

Koneska (2013: 16) states ‘changes to the mining sector’s legislative and regulatory regime are relatively frequent across the region. Partly driven by adjustments required by the EU law and partly in response to volatile investor interest, changes to tax rates, royalties and permit regimes are often substantial and can take a considerable amount of time to adopt and implement, increasing the uncertainty for interested companies.’

For example, Koneska (2013: 16) reflects ‘when the Albanian government adopted a new mining law in 2011, in annulled 43 licenses issued under previous regulations’, this act caused a substantial amount of concern amongst foreign investors in the region. The economic crisis of 2008 triggered even greater concern in the region as with the rest of Europe when investment was curtailed, revenues were subdued and the regional governments were seeking ways to maintain revenues by raising taxes and royalties.

Koneska (2013: 17) continues by reflecting on the opportunities for stifling bureaucracy and corruption as the mining legislation is slowly implemented. Without doubt there is an uncomfortable conflict between the rising EU requirements for complete transparency in all transactions between the mining companies and the host states and the pervading corruption. The passage of time will however embed the EU modelled legislation and the need for transparency, the bigger mining companies and international EPCM companies have well entrenched ethical standards. Koneska (2013: 17) concludes with the statement ‘mining is likely to become an increasingly important part of economies in the region. Despite threats pertaining to regulatory uncertainty, excessive bureaucracy and corruption, some encouraging signs signal a gradual improvement in the operating environment for mining companies, especially in the EU member states. An openness to new investment in the mining sector and the adoption of EU mining legislation are likely to make the business environment in the region less complex, enabling companies to access the rich mineral deposits in these countries.’

Anon (2013b1: 6) discusses the performance of one of the gold miners in Burkina Faso with gold resources reaching 3.1Moz. Burkina Faso is striving to present a good investment climate: a safe and stable investment climate, sincere communication, physical security for assets and personnel, environmental management and sustainable development, and good relationships between the mining companies and local communities with the benefit of a residue of learning.

Anon (2013b2: 7) further discusses the political situation in Burkina Faso; the state has developed and promulgated legislation that recognises the importance of mining benefits and revenues; low taxes on income and corporate profits, three-year tax holiday during construction and a 10% free carried interest. According to Anon (2013b3: 11) Burkina Faso has an abundance of mineral
resources including ferrous and non-ferrous metals, phosphates and clays, the most prominent metal resource being Gold.

Dorizo (2012: 21) reflects on the challenges in getting going in mining in Russia. Revocation of mining licenses is certainly a possibility; emergency situation, danger to life and health, threat to state security, early termination of an exploration license. These are the uncontrollable factors from the licensee point of view. There are also some aspects that are clearly in the control of the licensee; failure to comply with regional legislation, violation of terms of the license, failure to start an operation at the specified time and not meeting financing obligation for the project. These conditions would not be unique to Russia so the licensee has to beware of the conditions of the license and should have these aspects and conditions in mind at the start of the operations.

Obank and Gollaglee (2014: 20) wrote an article titled ‘Cracking Down on Bribery’ state the ‘mining and mineral industry worldwide has to a large extent been able to operate without proper regulatory scrutiny’. Obank and Gollaglee (2014) continue stating that the mining concessions established in developing counties were negotiated the periods of armed conflict or under a dictatorship regime. Terms such as conflict minerals and blood diamonds have been developed to describe the environment under which these mining leases have been developed.

Obank and Gollaglee (2014: 20) have indicated that there is increasing awareness of legislation designed to ensure the mining leases for these areas are negotiated in terms of national and local legislation; this is aligned to the objectives of the major international investors. The US with their Foreign Corrupt Practices Act and the Bribery Act from the UK is in place to ensure greater transparency in the negotiation of mining rights and leases. Anti-corruption laws have been tightened up in Brazil, China and Russia and India is in line to follow suit. Obank and Gollaglee (2014) continue ‘a number of high profile global mining operators have been in the news recently for alleged corrupt practices’.

To avoid these risks in the future we may see that some of the big players in the industry might choose to avoid countries or regions where there is not complete transparency or where the business practices are questionable. Other companies state Obank and Gollaglee (2014), who have confidence in the integrity of their procedures and controls may take the competitive advantage.

Obank and Gollaglee (2014: 21) conclude stating ‘needless to add, alleged corrupt practices, or question marks over reputation, can hand significant leverage to a buyer of a distressed business and erode value for secured lenders, creditors and investors. In some cases, it might put off partners entirely. Robust policies and the ability to demonstrate compliance are essential in today’s global market’.

Anon (2011c2: 7) describes the growth that mining companies such as Alacer Gold, Eldorado Gold and Koza Gold with significant USD investments. Anon (2011c2: 9) describes the changes to the mining legislation this is geared to committing mining companies to a planned spending on
their prospects and the necessity to commit to a time line. This is designed to prevent companies holding ground with no commitment to invest.

Anon (2013r1: 1) also reflects on the nationalisation of resources of ‘soft resource nationalisation’. They state ‘Companies should brace themselves for an upswing of “soft resource nationalism”’. Further ‘A current draft law suggests a greater focus on project linked development and local content requirements, and tax increases though they are not expected to be onerous’. The quote in Anon (2013r1: 1) continues ‘With local elections in the offing the government could be expected to come under more pressure to extract more money from the resource companies’. In this African state there was political tension during the course of the elections and some of the mining houses chose to withdraw some of their non-critical employees’ families.

Labeau (2014: 15) in an article titled ‘Aboriginal-rights cases could weigh on Canadian mining’ discusses the court decisions which highlight the need for recognition of land-use benefits beyond minerals and development. ‘Since the 1990’s a number of court decisions have established the legal framework applicable to the rights of Canadian aboriginal people’. The court identified three requirements to ground the aboriginal title; sufficiency of occupation prior to the assertion of European sovereignty, continuous occupation, exclusive occupation. Clearly there are rights of ownership the need to be ascertained during the rights application process.

The mining industry must have a social conscience in order to be able work to the benefit of the community in which its mines are located. Elliot (2013: 16) in an article titled ‘Adding value, communicating shared value is vital for companies to maintain a social licence to operate’ reviews the changing relationship between the mining community and the communities living in the areas in which they operate.

Elliot (2013: 16) discusses the ‘increasingly savvy stakeholders’, ‘the community and governments are developing a more sophisticated understanding of mining and metals activity and its potential impact, raising specific worries and increasing their scrutiny’. Elliot (2013: 16) continues the ‘Anti mining agenda in communities’, ‘there is a risk that active issue-based community groups can be manipulated by politicians and other groups with wider political agendas and magnify the challenge of community consent. There is strong evidence of some anti-mining non-governmental organisations tapping into community concerns over issues such as water access or loss of artisanal mining rights to prevent large scale mine development from occurring.’ Elliot (2013: 16) also reflects on the ‘global climate change concerns and increasing regulation mean that it may not be possible to exploit fossil fuel reserves, resulting in stranded assets and high exposure for investors’. Elliot (2013: 16) looks at early engagement with the local communities and developing a shared value measure to be communicated, ‘measuring and reporting on this shared value can be a valuable tool for a company in maintaining a SLO, as well as becoming more strategic and resilient in how it does business.’
The mining industry is clear closely linked to the politics of a country and the polls and outcome of the Australian elections was much in the mining media in the last quarter of 2013. The liberal party was leading in the polls and had every prospect of winning the election. Anon (2013i1: 3) in an article titled ‘Tax incentive ‘critical’ for Australian explorers’ reflects on the ‘confidence boost provided by a proposed tax break for Australian explorers was critical in a period of financial uncertainty according to the Queensland Resources Council’. According to Anon (2013i1: 3) the Liberal Party of Australia wanted to reverse the negative trends in the Australian mining industry by encouraging exploration and repeal of some legislation and reducing other forms of taxation.

On the positive side not all news has to be negative Anon (2013j2: 6) in an article titled ‘Industry backs Abbott after election win’. Anon (2013j2: 6) continues stating the ‘victory was welcomed by the resources industry, rattled by policies implemented by the previous labour administration, which was in power since 2007’. According to Anon (2013j2: 6) the minerals resource rent tax and carbon tax were blamed for crimping investment and raising cost.

Anon (2013j2: 6) reflects on the Australian mining industry being in the doldrums for a long period of time and expecting to be on a path of reinvestment hoping to be restored to international competitiveness. To encourage this point of view the new administration has pledged to scrap the MRRT, introduce tax breaks, clamp down on militant unions and remove red tape on mineral exploration. According to Anon (2013j2: 6) the aim of the new administration was to ‘reboot the mining boom’.

In the international investment environment key changes should not go by without being analysed for impacts, Anon (2013a4: 15) in a report titled ‘limiting foreign investment’ the appointment of a new Guinean president and his institution of mining reforms had an almost immediate effect on limiting and reversing investment in the mining industry. According to Anon (2013a4: 15) the legislation had the combined effect of lifting the minimum investment threshold to USD1 billion, increasing import duties and royalties. Guinea relies heavily on the mining industry with around 25% of the GDP attributable to mining, and according to Anon (2013a4: 15) investment in Guinea was severely curtailed.

From Anon (2013a4: 15) Africa has a large percentage of the world’s unexplored mineral resources, but should find a balance between economic returns for their nations against the understanding that mining companies and their cautious investors will not invest where there are not fair and comparable returns. Following on from these developments which caused a massive curtailing of capital investment in the Guinean mining industry came a revision to the mining legislation in 2013. Campbell, Beinsan and Denizot (2013: 14) discuss the changes to the legislation ‘although not ideal, the new mining code is more investor friendly and is a move in the right direction’.

Sekinah (2013: 3) reflects on the penalties that can be invoked should the miner not comply with mining legislation. ‘The Columbian government has revoked the permits of 32 mine operators,
alleging mining law infringements’. Sekinah (2013: 3) says that the majority of the operators were coal miners and the infringements were unpaid taxes and duties, the miners with revoked concessions cannot mine for another five years and would be required to dismantle surface structures and begin rehabilitation exercises.

Singleton (2013: 23) looks at the good prospects in Canada, Singleton (2013) quotes that ‘Canada has been the top destination for mining exploration for 19 out of the past 33 years’, there is a warning however that the investors must not become complacent and should continue to innovate in a sector that contributes CD35 billion to the nation’s GDP and employs 320000 workers. Over the next decade there was an estimated CD140 billion in project investments. With mineral production contributing 22.8% to Canadian exports this is certainly an industry that requires careful consideration and control to ensure sustained growth. In conclusion Singleton (2013: 24) states that ‘Canada ranks among the top five countries in the global production of 11 major minerals and metals but has fallen from the top five in gold, silver, zinc, copper and molybdenum’.

Though looking at International aspects of the mining industry the regional aspects should not be ignored. In a review of the mining aspects of the state of Nevada Singleton (2013) comments on the new tax bills that ‘could threaten to take the shine of Nevada’s mining sector’. According to Singleton (2013: 19) the mining industry contributes 5.2% to the states GDP the minerals mined in Nevada include gold 5.6Moz, silver 8.5Moz, copper 65916 tons and molybdenum 224 tons. Nevada is considered internationally to be one of the best locations for mining from a taxation point of view falling in behind Ontario, Sweden, Finland and Chile. According to Singleton (2013: 12) this was all due to change due to the states 5% cap on the net proceeds of minerals tax. The state lawmakers want to repeal this and lift the taxation level to 10%. This could have a serious effect on the mining industry in Nevada that in recent years has become the US single biggest producer of gold. Singleton (2013: 12) quotes thus ‘it worries me that if we don’t get out there and educate people this bill will pass, it’s really scary because people don’t understand the mining companies. Costs have skyrocketed and it is very difficult to get gold out of the ground. If it does not pay, they are not going to do it.’

Anon (2011a1: 3) reviews the prospects of mineral resources in Armenia - the mineral resources of this land locked state include molybdenum, gold, lead, sliver, clay and limestone. Armenia has an expanding economic base and steady progress has earned this country increasing support from the major international institutions. Armenia is also abundant in non-metallic minerals; these include basalts, granites, marble and nephelite syenite. According to Anon (2011a2: 9) Armenia’s taxation system is more lenient than Soviet Russia and rates well in areas such as obtaining credit, trading across borders and ease of closing business. Further Armenia is in the process of revising mining legislation, this as we have seen can be a time consuming and bureaucratic process but when complete will cover the prospecting licenses and the mining licenses covering periods up to 12 years and up to 25 years.
The implementation of mining legislation is subject to international scrutiny. Anon (2013c1: 3) wrote an article reviewing the BEE deals that allegedly had to be put in place to ensure the mining license for the South Deep project – then owned by Gold Fields would be granted and continued. According to Anon (2013c1: 3) former chairwoman Dr Mamphela Ramphele made claims that the South African government had provided a list of people to be included in the transaction to assure the mining license would not be withheld. The South Deep project attracted the attention of the US Securities and Exchange Commission according to Anon (2013j1: 3) proving that projects can receive international attention with what could be perceived to be local infringements. Negative sentiment in the international arena can have a serious effect on the investor’s confidence. From Anon (2013j1: 3) ‘Gold Fields Ltd said that the US Securities and Exchange Commission had launched a probe into the black economic empowerment deal over its South Deep gold mine, less than a month after the board had concluded its examination of the deal’. Anon (2013j1: 3) concluded ‘On confirming the SEC probe this week, Gold Fields said ‘it is not possible to estimate reliably what effect the outcome this investigation, any regulatory findings and related developments may have’.

4.2.2.8 Logistics

The mining developments can influence positively or be influenced by infrastructure development. Anon (2014a1: 5) discusses the Central America investment boom. Large scale infrastructure projects planned or underway in the region include Guatemala’s USD10 billion dry canal, El Salvador – Honduras USD5 billion coast to coast railway, Nicaragua USD40 billion inter oceanic canal and a USD5 billion Panama Canal expansion. These projects are to reinforce the infrastructure of the area and thus encourage and facilitate further growth in this area. According to Anon (2014a1: 5) these projects naturally come with some local resistance particularly with regard to the high levels of corruption bringing the belief that these projects will only benefit the economic and political elite.

Mining can play a significant role in the economics of countries as we can see in Burkina Faso. Anon (2011b4: 5) describes the difficult history of this African State the history of which started in 1919 when it was separated from the Upper Senegal and Niger. Colonisation by the French brought with it the development of the cotton industries and the creating of a road network. The decision to form the country was reversed in 1932 and the country was split amongst its neighbours, and the country was reformed in 1947 and gained independence from France in 1960. Military coups in the 1970’s and 1980’s brought President Compaoré to power, over 80% of the population are subsistence farmers.

From Anon (2012b1: 3) the Russia Far East has been a vital link for trade with countries such as China, Korea and Japan, though in history the relationships with these areas has been at time less than cordial. The reestablishment of the transport corridors in this area would certainly go a long way to expediting trade and opening up the area for easier mineral exploitation. Additionally
from Anon (2012b: 3) Russia’s relations with China were improving measurably which again would improve the prospect of mining in this area with the supply of energy, materials and equipment.

**4.2.2.9 Potash**

The potash market is a significant world market driver, from Yakubchuk (2013: 24) Russia holds the world’s largest supplier of potash as OAO Uralkali. Uralkali is a heavily vertically integrated potash producer with five mines, six plants and one carnallite plant in the Perm region of Russia. Being a major producer the company can manage to a certain extent the market place but the company was affected by the fall off in demand and the associated fall of in product prices.

Crust (2013: 12) discusses the Uralkali expansion programs; this could be seen as a response to competition in the market place and as an initiative to increase their control of the market. Crust (2013: 12) states that ‘Uralkali is looking to lift its production capacity to 19Mt/y of KCl (potassium chloride) by 2021, with the majority of investment, about USD2.3 billion due to be spent in 2015 to 2017.’ This expansion would push the Uralkali production of KCl to 40% of the world demand for the product.

Smith (2013: 21) reflects on the world potash market, ‘challenging times’ ‘if 2012 was a challenging time for the global fertilizer industry then a new superlative need to be found to describe 2013’. The global potash market was obviously being manipulated by the main suppliers into the market place and the demand was falling below the peak of 56.5Mt of 2011. Owing to the high levels of price manipulation intimated by Smith (2013) many of the big mining companies decided to sit on their prospects rather than commit funding to exploitation of these resources in a price depressed market.

**4.2.2.10 Diamonds**

The diamond industry has for a long time been a driver of mining projects and wealth.

Zimnisky (2012: 27) reviews in his article ‘Power Struggle’ the struggle to own the diamond business and to control the marketing and hence the pricing of the diamond market. Zimnisky (2012) discusses the De Beers strategy of controlling the diamond market for most of the 20th century where they as a company hoarded 80% of the supply of rough diamonds and controlled the release of these diamonds into the market place with price control as a major strategy.

De Beers held this monopoly position for many years then according to Zimnisky (2014) until the Russian State players started to erode the position of De Beers until the date of this article where De Beers and companies under their influence hold 35% of the market and Alrosa control 27.5%.

**4.2.2.11 Regional climate**

The far reaching quest for mineral resources has pushed exploration and exploitation in to harsher regions of the planet.
Anon (2013: 56) in an article titled ‘Poles Apart’ describes the challenges of mining in the extreme climates of North Eastern Russia. The particular Sentachan mine experiences temperatures ranging from -59°C to +27°C, a range of 86°C. The mining area is located 700km from the nearest town and relies on the road for winter access; helicopters are the means of access for the period when the road is impassable. The road is used for the supply of all materials and fuel. What happens to the road in summer, the road is constructed annually from the frozen beds of the Elgi, Utachan and Adycha rivers?

Developing on the theme of mining in extreme temperatures is the concept of mining at extreme heights. Anon (2013: 58) discusses the challenges of mining at high altitude ‘high altitude projects are particularly challenging. The majority of our (Bechtel) projects start as greenfield sites with limited or no existing infrastructure’. Anon (2013: 58) continues ‘all of the normal construction issues found at lower elevations apply to these projects, but when you add the complexity of working high above sea level; from construction roads to delivering power and water and dealing with high winds and other geophysical extremes it requires meticulous planning and best practice planning.’ Anon (2013: 61) continues by stating that mining companies will continue to search for new commodity sources for industry use, it is inevitable that the number of mining project being executed in these extreme remote areas will increase. Mining under extreme conditions will become the rule. Some of the highest mining projects are being executed in the Andes that bridge the gap between Chile and Argentina at altitudes around 4500m.

Domstad (2013: 62) discusses some of the challenges faced with construction work continuing in ambient conditions as low as -50°C. Lightness of materials and using where possible preformed bridge section obviates the need for carrying superfluous materials and the need for mixing concrete at -50°C. Materials such as sub-grade and ballast have to be heated prior to use to permit compaction. From Domstad (2013: 63) work place safety has to take into consideration the hypothermia and frostbite conditions that may exist. Domstad (2013: 63) states that ‘in arctic and subarctic regions, extreme cold weather of -50°C or below is experienced during the winter months. Combined with heavy snow, ice, freezing rain and strong winds, these climatic conditions pose risks to construction equipment, materials and people’. The client and execution contractors cannot afford delays due to weather conditions that are predictable. Construction techniques have to be developed to accommodate these conditions.

Welch (2009: 5) describes the poor weather in the Queensland area of Australia that was affecting the mining prospects in that area of Australia. 2009 saw prodigious rainfall in Queensland that was for a time causing flooding in Brisbane.

4.2.2.12 Environmental concerns

The mining industry, when examining areas with significant mineral resources has to consider the environmental impact of the proposed mine on the local environment.
Though environmental considerations are of significant concern there are still mineral deposits in the UK that are worth exploiting. On such of these is the Hemerdon project in the county of Devon in the UK. Tungsten is considered to be a mineral of strategic importance in Europe. According to Anon (2013n3: 16) the Hemerdon project is set to become one of the World’s largest producers of Tungsten. The project has received funding from Europe, North America and Australia. According to Anon (2013n3: 17) the project is expected to produce 345000 tons per annum of tungsten trioxide and 450 tons per annum of tin in concentrates.

The Pebble project has attracted significant attention, not for the prospects of this copper and gold deposits and the wealth it would generate for this area for this area but for the potential impact this project would have on the environment. Anon (2013c3: 17) states that ‘building a mine in the heart of a sensitive landscape – home to over 37 million Sockeye salmon – it’s too risky, both for the fish and the 14000 jobs that rely on them’.

According to Anon (2013c3: 18) over USD680 million has been spent by the developer on the Pebble project including USD159 million on environmental and socioeconomic studies. Even so respected academics have stated that either the salmon in Bristol Bay or the mining, both cannot co-exist in this area. Anon (2013c3: 18) quotes Robert Redford saying ‘the time has come for President Obama to take the next crucial step: to direct the EPA to use its authority under the clean water act to stop the Pebble Mine’.

4.2.2.13 Economics

The large multidiscipline mining project has the ability to affect the regional economics and the be affected by economic confidence.

Coates and Seaward (2013: 21) discusses the Central American region and the economic ties to North America. They write ‘the economic downturn in the US continued to severely affect all the Central American economies, which rely heavily on this market for exports.’ Coates and Seward (2013) summarised the regional activity thus; the most attractive countries for investment were Nicaragua and Guatemala and the country’s most indifferent to investment were Honduras, El Salvador and Costa Rica. Belize has very little economic activity and would clearly benefit from a structured exploration and mining industry to improve the balance of payments.

A review of mining economics would not be complete without a review of the Central and Eastern European nation of Bulgaria. Anon (2013f1: 19) states that ‘the mining sector is of considerable importance to Bulgaria’s economy, being both an important factor for both the country’s economic stability and energy independence.’

Anon (2013f1: 19) places Bulgaria in the European mining sector by placing it second in the production of gold and third in terms of copper production. The mining sector contributes 5% to the Bulgarian GDP and employs 30000 persons directly and another 120000 in related industries. The industry contributed USD300 million in 2013 with plenty of room for expansion.
Anon (2013f:1 9) states in conclusion ‘the (mining) sector is involved in prospecting, exploration, mining and processing of mineral resources. Today it ranks among the country’s most modern and innovative areas of endeavour in Bulgaria, and its role in the economy will become increasingly important as demand continues to grow.’

The International aspects of the mining industry fuelled particularly by the location of the main financiers and the locations of the main assets. In an article titled ‘DRC partners bag Finland deal’ Anon (2013a: 6) discusses the purchase of Kokkola cobalt processing operations in Finland by Lundin Mining Corporation and Freeport McMoran. These companies have a significant stake in the Tenke Fungurume copper and Cobalt operations in DRC. Anon (2013a: 6) indicates that as part of this deal the DRC state would end up with a 20% stake in the Kokkola operations.

4.2.2.14 Costs

Rising costs can have a significant effect on the mining industry, marginal mines can be closed and the reduced revenue stream can curtail or stop projects being initiated.

Cann (2013: 1) reflects on the challenges of doing business in Africa; he quotes thus ‘the mining industry has found itself between a rock and a hard place, the risk is the falling process, with little prospect of a recovery because of lacklustre demand. The hard place is the pressure on operating costs and the heightened threat resource nationalisation.’ These threats are heightened by the reduced access to financing; this is especially relevant for the riskier venture of mineral exploration. Cann (2013: 6) continues stating that the market place is expected to recover in 2017 to 2018 when the demand will once again meet with the reduced production of resources. The rising demand for resources will also reduce the reticence in going to the so called avoided countries in Africa such as the DRC.

Gleeson (2013: 5) discusses ‘Minas-Rio on time but the cash costs rise’. This reflects on the changing cash scenario experienced by many mining project in execution. In this case it was not the capital costs that were rising but the costs related to the operating costs of the mine. Gleeson (2013: 6) states that feedback from Anglo is that the operating costs were the major contributor to the operating costs for the project, the major contributors were: energy, inflation, labour, consumables, environment and land management.

4.2.2.15 Labour unrest

The South African mining industry in 2013 was severely affected by labour unrest. Anon (2014d: 3) in an article titled ‘SA strikes continue as violence escalates’, Exxaro Resources had five of their operation affected by industrial action early in 2013, this was at some of the biggest coal mining operations and the countries only refined copper operation at Palaborwa. According to Anon (2013d: 3) the action was over bonus payments and salaries and as we would see in 2014 this would roll over to the platinum sector. The industrial action in the coal sector would have a consequential effect on the power generation sector as the bulk of the steam coal is fed directly into the Eskom power stations. Anon (2013d: 3) stated that Exxaro was committed to continuous
engagement with the unions to avert a strike. ‘This will avert the possible negative effect that a prolonged strike could have on Eskom’s electricity generation and the country’s economy as a whole.’

According to Anon (2013a: 5) the strikes affected Gold Fields by as much as 15% off the previous year’s production losing 100000oz of gold. Industrial action is not unique to South Africa but has had serious consequences to the mining industry in South Africa due to the frail economics. Anon (2013b2: 4) reflected on the status of the platinum sector at the start of 2013 in his article titled ‘Amplats shuts South Africa mines after 13 injured amid inter-union row’. The two unions involved were the NUM and AMCU; injuries were sustained on both sides of the conflict and were sparked by inter-union rivalries. This followed on from the Marikana violence in the previous year where 50 people were killed in protests following demands for higher wages. According to Anon (2013b2: 4) Amplats (Anglo American Platinum Ltd) was in talks with the DMR (Department of Mineral Resources) regarding its intention to cut platinum production by 400 000oz/ annum with the resultant loss of 14 000 jobs as part of an economy drive.

4.2.2.16 Electricity supply

The mining industry is dependent on a supply of electricity and water. 2013 in South Africa was a poor year for confidence in electricity supply and many miners were forced into considering own supply of significant provision of own emergency capacity. These additional costs would have to be recovered from the mines revenue stream. Anon (2013r3: 8) discusses the call from Eskom in 2013 to reduce the demand for electricity; the call was for a 10% reduction in demand from the big electricity consumers including the smelters and refineries. The last time Eskom called for a general reduction in electricity consumption was in 2008. According to Anon (2013r3: 8) in the period of supply constraints there was a call to Gold Fields to cut the demand from its South Deep project by 25%.

4.2.2.17 Terrorism

The latest threat to mining and mineral processing projects will certainly be the rising threat of terrorist activities; either directly on the project site, attacks on senior management located in project offices or on the infrastructure that supports the mining project site. There have been reports of attacks on refineries in the oil exporting North African states, Anon (2013b1: 1) reported ‘Masked group raids Eldorado Gold’s Skouries project’. According to Anon (2013b1: 1) a group of 50 masked attackers broke into Eldorado Golds project in Greece at the weekend, assaulting security guards and setting fire to buildings and equipment. Though not directly a terrorist act, the activists are protesting against the damage to the environment and destruction of ancient forests. The article concludes with the statement ‘in our view the announcement highlights the risks associated with Eldorado’s project development in Greece and the potential for development delays.’
In a similar line Anon (2013a: 1) discusses in an article titled ‘Miners abducted by Colombian rebels’ some of the challenges to be anticipated with mining activities in the remote areas of the world. Anon (2013a: 1) writes the following ‘Canada based Braeval Mining Company said two employees and three consultants have been abducted from its Snow Mine gold project in north-central Colombia’. In response the mining company evacuated 22 staff by helicopter, and the site was fully evacuated. According to Anon (2013a: 1) the share price fell back by 12% on the news of this event.

4.2.2.16 International aspects closing comments

In closing this section, mining exploration has taken the mining industry to every corner of the world. The mineral resources have the ability to unlock unprecedented wealth for a nation becoming a significant contributor to the GDP, some are more amenable to mining operations than others in terms of licencing exploration and mining operations. Mining, environmental and labour legislation can present significant challenges to the mining company entering a particular market.

The negative aspects to be managed include; terrorism, corruption and extreme climate.

The miner has to take into consideration the regional labour resources and the regional logistics, the mining industry has the ability to transform the region and attract the positive benefits associated with the influx of resources and wealth.

4.2.3 Rescheduling, execution delays and expediting

Large multidiscipline mining project, requiring significant application of resources and money and being long duration projects could be subject to project rescheduling, execution delays and project acceleration.

At a mining entity called Alamos Gold Inc. according to Anon (2011c3: 11) this Turkish mining entity is expediting to development projects for completion in 2014. This is integral to increasing mineral resources to the 2Moz level. The project was expected to be expedited through the prefeasibility studies to execution. The production was expected to be in the region of 135000oz per annum and the capital expenditure for the project in the region of USD235 million.

The Zanga Iron Ore Company according to Anon (2013k5: 9) indicated that they would adopt a phased approach to the development plans for the project in the republic of Congo. The initiative was to reduce the capital cost of the project and to make use of existing infrastructure. The capital expenditure would be reduced from the initial USD7.4 billion to a more reasonable USD2.5 to 3.0 billion.

Aquila Resources was looking for investors for the USD6.9 billion iron ore project in Western Australia. According to Anon (2013k6: 8) there was concern that the current investors were not fully committed to the project. In 2013 there was a marked fall off in demand for iron ore from the major consumer, China, as their domestic growth stalled and showed no sign of an immediate recovery.
The GDP growth in China, according to Treadgold (2013: 13) fell from double digit numbers to 7.8% in 2012. From this Treadgold (2013: 10) was looking specifically at the deepening crisis in the Chinese economy that was for a long time the barometer of the success in the world mining industry. Treadgold (2013: 10) states that 'By now, after a week of news generated at the annual Hong Kong Mines and Money 2013 conference, some people will be tired of hearing about China and its importance to the world’s mining industry. They may even be encouraged to consider an alternative view – that China’s miracle economy is having a few problems.' From Treadgold (2013) the Chinese economy is slow to react to changing demands, in particular for aluminium, the Chinese bought and stockpiles 300000 tons of aluminium, and there was not the predicted growth in the steel demand causing the iron ore price to fall from USD145 per ton to a predicted USD100 per ton. As warehouses fill with unsold products the demand for un-beneficiated ore will tail off.

Lovesey (2009: 1) in ‘BHP feels the pinch’ states that ‘BHP Billiton, the world’s largest mining company, this week revealed plans to axe 6000 jobs or 6% of its global workforce, and pulled the plug on the Ravensthorpe Nickel mine in Western Australia, reflecting the growing strain on the industry’. BHP had for a long time resisted mine closures but the growing pressure from the pronounced downturn in the global economy from 2008 onwards and the drop in the commodity price for Nickel BHP had to relent and take action to protect the core of the company. It was obviously a bad start for the year for BHP and jobs were cut at Cerro Colorado, Esconsilada and Spence Copper mines in Chile.

Lovesey (2009: 1) also reflected in the actions being taken by Rio Tinto in his article ‘Rio Tinto unveils cost-saving measures’ he stated ‘Rio Tinto this week revealed details of a series of production cuts and job losses in line with plans to conserve cash and reduce debt’. The cuts appear to have been focussed on the copper and aluminium production sections of the company. This was in line with the drop off in global demand for these products and was detailed on the industries that were the least profitable for the company. Though job cuts were the most visible of the cuts the capital expenditure in these areas was also halved.

Anon (2009a1: 3) showed in his article ‘Gold poised to rally on deepening economic crisis’ that to every recession there is a haven for investors. He states ‘Gold prices may reach an all-time high in the first six months of 2009 on surging investment in the precious metal and a haven amid the current economic turmoil. The investment surge was from investors in Europe and North America. Though there was an investment surge there was little effect on the mining companies, allowing a brief respite from austerity and recover from existing investments’.

The BHP Billiton cuts of 2009 were reflected in the reduction effected at the Olympic Dam project. According to Anon (2009a2: 7) ‘during the review process, and consistent with the prevailing economic conditions, the group will reduce activity at the project. Only work to support the approvals process, and to examine mining and processing options will be carried out’.
Being fundamentally linked to the commodity pricing and the economy of the host country means that the LMM Project could be subject to rescheduling to both slow down and accelerate the project. Projects of such size and cost could be funded by revenues and as such would be run on the availability of cash. These articles have shown that the mining industry is very much in a supply and demand position, the inertia associated with large mining project means that it is not possible to match the demand and often the mining houses have to resort to more strategic measures. Sales fund the capital projects and some mining houses have resorted to slowing the capital spend and encouraging the mining companies to be more circumspect in their capital spending.

4.2.4 Budget cuts and capital re-scheduling

Linked to the previous section this section examines the prospect of budget cuts on project and capital rescheduling. The articles below look at the drivers for these and the results of these activities.

Hoffman (2013: 19) reflects on the falling gold prices of 2013 where the gold price dropped by 25% in the first nine months of the year. The author states that 2013 was the austerity year for the gold mining industry. Hoffman (2013: 19) states that ‘one look at headlines dominated by cutbacks, closures and delays shows how fully the miners have returned to their old cost conscious ways’. This was so much so that the capital expenditure by the 18 bigger mining companies in 2014 was predicted to be USD 30 billion (or 33%) less than in 2012. This prediction was expected to be conservative with a potential of as much as 50% cut expected. The cuts impact the supply of gold immediately with, according to Hoffman (2013) a shut-down of 20 to 25% of the production.

McGloin (2013: 25) discusses in his article the cost cutting drive of Amara Mining PLC; this was particularly in the exploration expenditures that are instrumental in the life extension of the mining company. This was initiated by the fall in the value of gold in the 2013 period. The fall in April 2013 was the single biggest in 30 years. Cash conservation became the new industry catch phrase for the period. Further McGloin (2013: 25) states that the ‘mid-tier producer Iamgold Corp announced cost cutting measures, but on a different scale’. This Canadian miner announced cost cutting measures of the scale of USD100 million.

According to McGloin (2013: 27) South Africa has always been seen as one of the higher cost gold producers with up to two thirds of the sector being loss making. AngloGold Ashanti in particular embarking on a cost cutting drive with 75% of the head office staff being made redundant. In the same period according to McGloin (2013: 27) some of the gold producers have been forced to make production cuts of less viable operations. Barrick Gold chose to cease operations at some of their Tanzania mines to slow down the cash burn. Barrick Gold identified cost cutting measures that would ‘save’ USD185 million.

Anon (2012c1: 8) examines the business strategy of Atico Mining (copper) they are exploring in the Latin American region of Columbia for mid-sized high grade copper deposits that are capital expenditure efficient allowing faster turnaround for lower costs.
According to Holland (2012: 11) the gold mining industry has had to review the capital expenditure profile of many of their operations. Holland (2012: 11) writes ‘How have we done as an industry in terms of optimising our capital? Over the past 10 years, on an annual compound growth basis the gold price has risen by 20% annually, the industries capital expenditure on a per ounce basis, however, has gone up by 32% annually over the same basis.’ The growth in capital expenditure per ounce has been driven to the greatest extent by the investment in ‘green field’ development.

According to Holland (2012: 12) the complexion of some of the new project is changing in so far the project of the future in the gold mining sector would not be for growth but for ‘tonnage replacement’. In other word the new project would be for the sustainment of production levels.

The question that is more and more being have to answer is, according to Holland (2012: 12) ‘is can you guys deliver. The investors are asking management to be more prudent with their expenditure, investor confidence tends to affect a mining sector and not just a particular mine, particularly in the South African mining sector.

According to Anon (2012d1: 15) on the NYSE are some of the World’s largest gold producers and some of the fastest growing companies; Agnico-Eagle (USD104.6 million capital expenditure), Allied Nevada (USD40.9 million capital expenditure), AngloGold Ashanti (USD45.1 million capital), Barrick Gold (USD1.58 billion capital expenditure).

The key findings of an executive survey discussed by Anon (2013t1: 14) states that ‘the 2012 survey indicates that the mining industry remains cautious about the global economy and the near term prospects of the mining and mineral segments. Encouraging signs of growth in North America are offset by uncertainty in the EU and a potential Chinese slowdown, all of which translate into unpredictability for mining’. The survey according to Anon (2013t1: 14) ‘also highlights a change in attitude regarding capital investment. Here too mining companies are tending to look within. Instead of investing in developing new sites, the industry is favouring the expansion of operations at existing sites. The regulatory challenges associated with ramping up new operations and showing productivity within ever tightening timelines are no doubt contributory factors as well’.

According to Anon (2013z1: 14) the management of capital projects was a top priority for the mining companies. As stated above the mining companies were looking at more effective uses of capital and were thus channelling funding into to expanding operations at existing sites rather than new greenfield projects. Greenfield projects represent serious risk. Linked to the expansion projects was the renewed focus on more efficient mining methods and increasing the return from these assets with effective management and improved maintenance and better coordination of efforts.

Anon (2013k1/2: 7) discusses the failing fortunes of both Boseto and Aquarius. Aquarius chose to cut back on the overhead costs by reducing the overhead costs and Boseto was subject to a massive asset write-down. Boseto decided to issue shares subject to the approval of their shareholders.
Wilshaw (2009: 1) in an article titled ‘Oz Minerals recommends rescue package’ discusses the refinancing of a fellow Australian mining company. Even with the asset potential for prospective purchasers the company still faces AUD2.2 billion in impairments from underperforming mines.

Anon (2012a1: 3) in an article titled ‘Court suspends work at El Morro’ discusses the interruption of construction work on a gold/ copper project in Chile following the suspension of an environmental permit. This was enacted by the Supreme Court of Chile following a ruling that the indigenous people of the area had not been adequately consulted during the permitting exercise. The total project value was stated to be in the region of USD3.9 billion.

From Gleeson (2014e1: 1) reviewing the copper mining prospects in Chile, ‘while Chile’s State Copper commission is confident of the country’s copper prospects, not is as assured. With production costs climbing and the copper prices under the USD7000/ ton, the Latin American country needs drastic action to remain competitive’. Gleeson (2014e1: 1) continues by stating ‘According to Cochilco’s latest projections, USD105 billion in investments has been lined up for copper, gold, silver, iron ore and industrial mineral project from 2014 to 2023.’ Obviously there is a substantial amount of confidence required to provide and support this level of investment.

Gleeson (2014e1: 1) intimates that in the immediate past no project investment has fallen through even though the copper production costs in Chiles have risen by 335% in the period 2004 to 2012. This outpaced the commodity price increase of 250% in the same period. Copper is of great significance to the Chilean economy, from Gleeson (2014e1: 1) copper contributed USD14 billion to the economy, this had fallen to USD8 billion in 2012.

Anon (2013l2: 6) discusses the continuing effect of Barrick Gold’s continuing cost cutting, ‘the world’s largest gold producer by sales would focus on five core operations in the America’s as it sought to cut costs and reduce capital expenditure.’ Barrick’s operations produce 7Moz to 7.4Moz per annum, in asset shedding activities they sold off Australian operations and its energy business. Gold/ silver projects in South America were deferred saving the company USD1.8 billion for FY17.

Locally, in 2013 construction work at the USD2 billion Venetia project began. According to Anon (2013n1: 3) ‘This was a significant investment in the South African diamond mining industry as Venetia moved from an open pit mine into an underground operation’. The project was considered significant enough to attract the attention of the State President. Diamond mining in South Africa according to Anon (2013n1: 3) had invested USD20 billion even though De Beers had been cutting back on investment over the preceding period.

Maintaining a view of the local South African mining industry according to Anon (2013n2: 7) the Wesizwe project where investments equalling USD506 million are required to complete was giving some of its investors a loss of confidence in the project viability. The immediate budget for the following six months of the project cash flow (USD21.7 million) was not forthcoming from various partners.
Ehlers (2013: 48) discusses the international perceptions regarding investment in the mining industry in Africa. Ehlers (2013) states that ‘despite Africa’s proven and potential wealth in resources, raising the finance to realise this wealth treads a tight rope between development costs and the local infrastructure required to export the product, and the continued commodity price volatility risk. Ehlers (2013: 48) continues describing the size of the potential for the mining industry ‘Africa has the world’s largest known reserves of platinum, chromium, and manganese, half the planet’s cobalt and diamonds and, even today, a large percentage of its proven gold deposits along with rich copper, iron and coal reserves.

Ehlers (2013) discusses the challenges of Africa as being raising the financing for the extraction and also to develop the infrastructure to transport the product to the point of shipping. Also the availability of electricity in Africa precludes the first stage of beneficiation. The bulk transportation required for products such as iron ore, manganese and coal means that these products remain below their potential for exploitation whereas precious and semi-precious stones can be transported more easily and have received investment.

Treadgold (2013: 10) intimated a recovery in the mining sector in his article with the subheading of ‘successful capital raisings and assets sales are cause for optimism’. Some of the smaller miners were encouraging the investors to venture some capital. Treadgold (2013: 10) discusses the capital improvement factors thus: ‘investors are blowing the dust cheque books to support capital raisings’, ‘as a positive signal for other potential capital raisings, there is nothing better than the good will by a fast profit for investors;’ ‘the revival will be disjointed with only the highest quality issuers getting the capital they require in the early stages of a recovery,’ ‘of greater significance than a handful of successful capital raisings by smaller explorer miners is the success of asset sales, or asset purchases, to give the deals a more positive spin,’ ‘the key point is that deal flow is picking up, assets are being transferred and fresh capital is being injected into mining’.

Treadgold (2013: 12) reflects on the budgets cuts of 2013 and the ‘diminishing cash pile’ and the effect that this has on the mining equipment suppliers. Treadgold (2013: 12) states that ‘large miners such as BHP Billiton alone have stripped billions of dollars from their respective cost bases in the past year’. ‘This is having a debilitating effect on equipment suppliers and service providers, which are suffering a contraction in demand for their products.’ ‘At the smaller end of the sector, a value gap has opened between the haves and the have-nots’. ‘According to recent reports, 191 explorers listed in Australia have insufficient cash to fund a single quarter’s cash burn’. Mining is driven by exploration and Treadgold (2013: 13) reflects on the reducing amount of money available for the exploration activities they reviewed the 861 stocks on the Australian Securities Exchange 321 had less than AUD1 million in cash.

From Treadgold (2014: 12) was a year that started with an air of optimism from figures published for 2013. Rio Tinto was reporting strong results from operations in 2013. Also from Treadgold (2014: 12) ‘This time around the surprises are more likely to be on the upside at all the big miners.'
To give them their dues, they have worked hard to cut operating costs and invest only in projects that generate the biggest returns."

According to Treadgold (2014: 13) though shares in Rio Tinto were in a strong recovery the question unanswered was when was this recovery going to filter down to the mid-tier miners and the smaller miners and the smaller producers and the explorers at the bottom end of the food chain. Only then could this be considered to be an industry recovery. Treadgold (2014: 13) could not report good news for all of the industry sectors in the mining industry. The gold sector was still suffering from a poor gold price and this was threatening a big gold write-down. From Treadgold (2014: 13) the gold price fell in 2013 from USD1681 to USD1201 per ounce. This 28% fall would cause the gold miners to write down assets thus affecting investors’ confidence and making marginal operations non-viable.

Resource nationalism is seldom far from the discussions in mining houses. According to Anon (2013s1: 1) rising commodity prices is initiating disputes between mining companies and the host governments. From Anon (2013s1: 1) the escalating tension is ‘threatening the fortunes of many resource rich countries and putting billions of dollars of investments in limbo’. Further Anon (2013s1: 1) notes the trend that as the commodity prices increase and the strategic importance of the minerals increases so does the increases in mining taxation. This it appears is not linked to the development of the country but appears to be a natural response of all governments to perceived value indigenous of natural resources.

Anon (2013r2: 6) reflects on the dramatic changes that can take place in the mining industry in his article titled ‘Cliffs indefinitely suspends Ring of Fire chromite project’. The article cites various reasons for the suspension of the project in particular the uncertain time line and the necessity to establish extensive infrastructure. In the background according to Anon (2013r2: 6) was the slow and uncertain progress towards the environmental assessment process and the issues regarding the surface land rights. The project could have yielded USD3.3 billion in project activities for the northern Ontario Ring of Fire region.

Not all mining projects require large budgets for exploitation; from Anon (2013h1: 8) an USD13.5 million open-pit project was identified in Zimbabwe to exploit a tungsten resource. The ammonium paratungstate (APT) deposit is owned by Premier African Minerals. Being an open cast project the lead time to production would be very short, according to Anon (2013h1: 8) this would be in the region of 10 months. Naturally being a Zimbabwe based project there would be some international reluctance to be overcome even with such a low capital requirement for start-up.

In a similar line an anthracite project in British Columbia has an estimated start-up capital requirement of a modest USD62 million. According to Anon (2013h2: 11) the up-front capital would be required for the construction of access roads, surface infrastructure and portal development. The cash generated from sales would then be used for reserve definition and expansion drilling,
as the mine progresses the mine would seek further independence with the procurement of plant and equipment.

The changing fortunes of the international mining industry is well documented. There is a constant necessity to match the supply potential of the industry to the demand of the users. Where this is imbalanced or there is a tail off in demand then the value of the commodity will fall. Financiers are also cautious when funding LMM Projects as project success is linked to external factors outside the control of the project team. The articles reflect on the rapidly falling gold price and the rapid fall in the value of copper in the market place. This has had the combined effect of placing some projects into hold. In addition this has affected the cash reserves of some of the big mining house and by doing this has caused some of the mining houses to re-examine the way that they are spending capital. Some of the large reserves in the mining rights will be on hold awaiting better capital prospects.

4.3 Conclusion

Chapter four was written to give context to the environment of the large multidiscipline mining project.

The following sums up some the challenges: Biggs (2013:19) wrote an article titled ‘Onwards and upwards’. Biggs (2013) stated that a recalibration would be required for the mining industry. Biggs (2013) identified the 10 trends published by Deloitte’s in the mining industry annual review:

- ‘The cost of contraction – mining productivity hits new lows – for the third year running the cost of doing business tops the trend reports.
- Matching supply to demand – market imbalances wreak commodity price havoc. Projects were being put on ice instead of companies restructuring their portfolio to take advantage of future shifts in demand.
- Remaking mining – exploring the innovation imperative. Adopting new technologies.
- Finding funding – debt up, deals down and juniors fight for survival. The slip in profitability and the rise in industry impairments have made funding harder to find.
- The project pipeline stutters – record impairments call capital allocation practices into question. Companies must examine their project pipelines, adopt robust project scoping processes, robust governance systems and control systems.
- Power to the people – local community demands intensify. Appropriate community investments to encourage support and productivity.
- Resource nationalism spreads – government relations marked by rising hostility. Spreading to previously passive regions is a concern even though resource nationalism is not a new concept.
- Crackdown on corruption – zero tolerance regulatory environment complicates compliance. Companies to ensure the internal controls are robust and audited.
• Changing the safety equation – from zero harm to zero fatalities. With new risk analysis techniques and analysis of historical data.

• A dearth of skills – the talent gap widens into executive suites. Investing in the best people, standardising operating systems and embracing new training environments.’

Large multidiscipline mining projects require large sums of capital, can take place in remote locations in countries that often have fledgling economies and require significant infrastructure development.

Thus the implementation of a mining project can have a significant effect on the economy of the host nation.

In chapter five the key aspects of the literature review are transposed into a questionnaire, this is designed to examine the level of understanding of the challenges facing the EPCM Company and to identify any novel techniques implemented to address these challenges.
Part 3 – Empirical study

Chapter 5: Interviews

5.1 Introduction

In chapter five a research instrument, developed from the key points of the literature review is discussed with the persons selected from the host EPCM Company and one person from the client group.

The research instrument was constructed and the interviews were carried out to establish the level of appreciation and understanding for the topics and key aspects identified during the course of the literature review.

The key aspects identified included the main causes for project failure and it was intended to establish the interviewees' understanding of causes for project failure in the project in execution.

5.2 Structured research instrument design

The research instrument was developed from the literature review topic groups and the key discussion points identified in those groups. The extensive research instrument was designed to test the understanding of the topics, test the discussion points, to encourage discussion on the topics and elicit insight beyond the discussion points.

The research instrument shown below has indicative discussion points in the right hand column, these were to allow the interviewer to trigger if necessary discussion and not to lead the discussion.

The fundamental principle was to cover the aspects and research identified in chapter one.

5.3 Interviewee group

The EPCM Company that was the focus of the study and the interviews had five large multidisciplinary mining projects running at the time of the empirical research being conducted there were five different clients, all of the project managers and two senior engineers engaged on these projects were interviewed. The management of these five projects was considered representative and exhaustive. One interview from a client group was included in this sample as a control and to give a client perspective on the activities of an EPCM Company, where used these comments are indicated.

In total eight interviews were set up with senior persons involved with large multidiscipline mining projects, seven were from the EPCM Company and one interview was from the client group.

The identity of the respondent is not revealed.
Interviews with other EPCM Companies would not have been possible due to the sensitive nature of the items being discussed.

### 5.3.1 Interviewee profiles

<table>
<thead>
<tr>
<th>Interview One</th>
<th>EPCM Global Director: Mining Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>53</td>
</tr>
<tr>
<td>Qualifications</td>
<td>Higher National Diploma (Mech), GCC Mines and Works, PMP</td>
</tr>
<tr>
<td>Project Experience</td>
<td>29 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Two</th>
<th>EPCM Senior Engineering Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>56</td>
</tr>
<tr>
<td>Qualifications</td>
<td>BSc (Hons), GCC Mines and Works, PMP, Pr Cert Eng</td>
</tr>
<tr>
<td>Project Experience</td>
<td>30 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Three</th>
<th>Client Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>53</td>
</tr>
<tr>
<td>Qualifications</td>
<td>Higher National Diploma (Mech), GCC Mines and Works</td>
</tr>
<tr>
<td>Project Experience</td>
<td>28 years of project and project management experience in the mining industry.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Four</th>
<th>EPCM Senior Project Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>37</td>
</tr>
<tr>
<td>Qualifications</td>
<td>GDE (Wits), BSc Mech, Pr Eng</td>
</tr>
<tr>
<td>Project Experience</td>
<td>17 Years, 8 Years in Mining Projects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Five</th>
<th>EPCM Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54</td>
</tr>
<tr>
<td>Qualifications</td>
<td>Higher National Diploma – Mining, GCC Mine Manager</td>
</tr>
<tr>
<td>Project Experience</td>
<td>13 Years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Six</th>
<th>EPCM Portfolio Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54</td>
</tr>
<tr>
<td>Qualifications</td>
<td>Higher National Diploma – Mech, GCC Mine Manager, PMP</td>
</tr>
<tr>
<td>Project Experience</td>
<td>35 Years with 8 Years in an EPCM Company</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Seven</th>
<th>EPCM Senior Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>36</td>
</tr>
<tr>
<td>Qualifications</td>
<td>BEng (Mech), PMP</td>
</tr>
<tr>
<td>Project Experience</td>
<td>9 Years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interview Eight</th>
<th>EPCM Senior Project Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>38</td>
</tr>
<tr>
<td>Qualifications</td>
<td>BEng (Mech), PMP, Pr Eng</td>
</tr>
<tr>
<td>Project Experience</td>
<td>17 Years with 10 Years in Mining Projects</td>
</tr>
</tbody>
</table>
5.4 D Phil - Research instrument

<table>
<thead>
<tr>
<th>Faculty</th>
<th>Engineering and the Built Environment – Post Graduate School of Engineering Management University of Johannesburg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>“An Extended PMBoK Project Management Model for Companies Delivering Large Multidiscipline Mining Projects.”</td>
</tr>
<tr>
<td>Interviewer</td>
<td>Michael Yates</td>
</tr>
<tr>
<td>Student number</td>
<td>2005 11322</td>
</tr>
<tr>
<td>Interviewee</td>
<td>-Name omitted in final text-</td>
</tr>
<tr>
<td>Project name</td>
<td>-Title of the project-</td>
</tr>
<tr>
<td>Project description</td>
<td>-Brief description of the project-</td>
</tr>
<tr>
<td>Project start</td>
<td>-Start date-</td>
</tr>
<tr>
<td>Project duration</td>
<td>-Years-</td>
</tr>
<tr>
<td>What project phase are you currently in?</td>
<td>-Current phase of the project-</td>
</tr>
<tr>
<td>Project value</td>
<td>-ZAR-</td>
</tr>
<tr>
<td>Nota bene</td>
<td>All aspects discussed will be held in strictest confidence</td>
</tr>
</tbody>
</table>

5.4.1 Project leadership

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| Describe your leadership style. | • Transformational  
• Transactional  
• Empowering  
• Laissez-faire  
• Machiavellian (strong power base) |
<p>| Is the same management style used for all situations and for all team-members? | |
| Has your project required a change in leadership style during execution? | |
| Does your leadership style positively influence team performance? | |
| How would you say your leadership style has affected the work performance of your subordinates? | Team work performance. |</p>
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What skills should a project manager possess?</td>
<td>• Team building skill,</td>
</tr>
<tr>
<td></td>
<td>• Leadership skill,</td>
</tr>
<tr>
<td></td>
<td>• Conflict resolution skill,</td>
</tr>
<tr>
<td></td>
<td>• Technical skill,</td>
</tr>
<tr>
<td></td>
<td>• Planning skill,</td>
</tr>
<tr>
<td></td>
<td>• Organisation skill,</td>
</tr>
<tr>
<td></td>
<td>• Entrepreneurial skill,</td>
</tr>
<tr>
<td></td>
<td>• Administrative skill,</td>
</tr>
<tr>
<td></td>
<td>• Managerial support building skill,</td>
</tr>
<tr>
<td></td>
<td>• Resource allocation skill.</td>
</tr>
</tbody>
</table>

| What selection criteria are used for Project Managers?               | • Personal skills,                                                                                                                          |
|                                                                      | • Project management skills,                                                                                                                  |
|                                                                      | • Business skills,                                                                                                                          |
|                                                                      | • Technical skills,                                                                                                                          |
|                                                                      | • Quality skills,                                                                                                                           |
|                                                                      | • Time for decision making.                                                                                                                  |

<table>
<thead>
<tr>
<th>How do you deal with the internal (Company) administration?</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>On what criteria should a Project Manager be evaluated?</td>
<td>• Amount of required administrative activity,</td>
</tr>
<tr>
<td></td>
<td>• Difficulty of project leadership,</td>
</tr>
<tr>
<td></td>
<td>• Management support,</td>
</tr>
<tr>
<td></td>
<td>• Risk of being treated unfairly,</td>
</tr>
<tr>
<td></td>
<td>• Trustful relationship.</td>
</tr>
</tbody>
</table>

### 5.4.2 Human resources and knowledge management

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the company have knowledge management processes?</td>
<td>Transfer, creation, assimilation, storage, organisation, protection, application, validation, verification, and identification.</td>
</tr>
<tr>
<td>Do policies exist for Tacit and Explicit Knowledge management?</td>
<td></td>
</tr>
<tr>
<td>Do policies for capturing knowledge exist?</td>
<td></td>
</tr>
<tr>
<td>Does tacit knowledge get captured into computer tools?</td>
<td></td>
</tr>
<tr>
<td>How do you encourage the divulgement of tacit knowledge?</td>
<td></td>
</tr>
<tr>
<td>How do you manage knowledge gathering in environments of overload,</td>
<td></td>
</tr>
<tr>
<td>ambiguity and politics?</td>
<td></td>
</tr>
<tr>
<td>What is the strength of the engineering culture within your project/</td>
<td></td>
</tr>
<tr>
<td>company?</td>
<td></td>
</tr>
<tr>
<td>How is the ‘Engineering Culture’ modified to the benefit of the project</td>
<td></td>
</tr>
<tr>
<td>executables?</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Is knowledge gathering always successful?</td>
<td>• Favourable conditions,</td>
</tr>
<tr>
<td>• Overload conditions.</td>
<td></td>
</tr>
<tr>
<td>Is knowledge management a primary concern?</td>
<td></td>
</tr>
<tr>
<td>How do you sensitise the project team to knowledge gathering?</td>
<td>Even in stressful environments</td>
</tr>
<tr>
<td>How do you provide the team time for effective recollection?</td>
<td></td>
</tr>
<tr>
<td>How do you ensure that corporate knowledge databases are used effectively?</td>
<td></td>
</tr>
<tr>
<td>How is the learning disruption from disrupted projects minimised?</td>
<td></td>
</tr>
<tr>
<td>Does your client understand the full effect of project disruptions?</td>
<td></td>
</tr>
<tr>
<td>Do you see knowledge management as a driver of innovation?</td>
<td></td>
</tr>
<tr>
<td>How is recorded knowledge utilised to the benefit of the company?</td>
<td></td>
</tr>
<tr>
<td>Do you see knowledge management as a means for attracting top talent?</td>
<td></td>
</tr>
<tr>
<td>What are the corporate benefits of knowledge management?</td>
<td>• Cost reduction,</td>
</tr>
<tr>
<td>• Reducing time,</td>
<td>• Greater success assurance.</td>
</tr>
<tr>
<td>What are the corporate benefits of knowledge management?</td>
<td>Coping with complex and unpredictable projects, improving performance and capabilities. Competitive advantage.</td>
</tr>
<tr>
<td>What policies are there for the deployment of personnel into a project environment?</td>
<td></td>
</tr>
<tr>
<td>How are the personnel inducted into the project?</td>
<td></td>
</tr>
<tr>
<td>How do you ensure the team contributes their best to the project?</td>
<td></td>
</tr>
<tr>
<td>How does the company manage the effectiveness of the human resource?</td>
<td>• Recruitment,</td>
</tr>
<tr>
<td>• Selection,</td>
<td>• Appraisal,</td>
</tr>
<tr>
<td>• Development,</td>
<td>• Reward.</td>
</tr>
<tr>
<td>How is the competitive advantage of the human resource secured and maintained?</td>
<td></td>
</tr>
</tbody>
</table>
### 5.4.3 Teams

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What drivers do you use to model and build your project team?</td>
<td>Genetic algorithm.</td>
</tr>
<tr>
<td>What are your main constraints when building your project team?</td>
<td></td>
</tr>
<tr>
<td>How are engineers’ skills identified and quantified?</td>
<td></td>
</tr>
<tr>
<td>How are team deficiencies identified and addressed?</td>
<td>• Cohesive project group,</td>
</tr>
<tr>
<td></td>
<td>• Economic allocation of scarce resources.</td>
</tr>
<tr>
<td>How do you or would you manage your virtual project team?</td>
<td></td>
</tr>
<tr>
<td>Are you using geographically dispersed project teams?</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>Define the term – ‘socialising’?</td>
<td>The conversion of individual into group tacit knowledge without attempting a priori to codify, or externalise, knowledge</td>
</tr>
<tr>
<td>What do you understand by ‘digital socialising’?</td>
<td>Virtual teams</td>
</tr>
</tbody>
</table>
| How would you encourage and facilitate team building with a geographically dispersed project team? | Includes:  
  - Conversations,  
  - Apprenticeships,  
  - Story-telling. |
| How is cross-firm socialising encouraged? |  |
| How effective are meetings in knowledge sharing in teams? |  |
| How effective is the telephone in team socialising? | No shared visual stimulus. |
| How effective is eMail in team socialising? | Slow and often ambiguous nature,  
  - Can become misunderstood and time consuming. |
| How effective is the company extranet in team socialising? | Too cumbersome,  
  - Too open. |
| How effective are web based project teams? |  |
| How do you retain your best people in an economic downturn? | Prioritise the retention/ development of talented people? |

### 5.4.4 Complexity and uncertainty

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| What do you understand by the term complexity? | Technological complexity  
  - Organisational complexity |
| What do you understand by the term uncertainty? | Complexity driven  
  - Major source of risks for the project.  
  - Gap between information and knowledge required making decisions and what is available. |
| How do you differentiate between risk and uncertainty? | Risk has known outcomes (known unknowns),  
  - Uncertainty has unknown outcomes (unknown unknowns),  
  - Absence of information about a risk factor. |
| What are the key drivers of complexity and uncertainty? | Project system size,  
  - Project interdependence,  
  - Project variety,  
  - Elements of context. |
| What are your sources and consequences of project complexity? | What makes your project complex? |
| How do you manage complexity? | Staff quantity,  
  - Staff diversity. |
<p>| What are the benefits of complexity? |  |
| What do you understand by project dynamics? |  |</p>
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What effect would significant project changes have on the project team?</td>
<td></td>
</tr>
<tr>
<td>What effect does pacing of the project have on project complexity?</td>
<td></td>
</tr>
<tr>
<td>What do you understand by information biases?</td>
<td>Systematic error</td>
</tr>
<tr>
<td>What would you describe as being the origins of biases?</td>
<td>Preferential memory, Processing of information, Output processes, Feedback processes.</td>
</tr>
<tr>
<td>How does your project team manage the many stakeholder relationships?</td>
<td>Knowledge, Skill and, Aptitude.</td>
</tr>
<tr>
<td>How does this skill develop?</td>
<td>Trial and error, Narrating differentiated, carefully balanced stories, Project team to have the competency and freedom to develop.</td>
</tr>
<tr>
<td>What pattern does this relationship follow</td>
<td>Fine-tuned to content, framing and timing.</td>
</tr>
<tr>
<td>How does the level of uncertainty vary during project execution?</td>
<td></td>
</tr>
<tr>
<td>How should the execution team address project complexity?</td>
<td>Team should be allowed to test own levels of competency, Learn where the skills were located in the client organisation.</td>
</tr>
<tr>
<td>What would you see as being the role of the client organisation in uncertainty management?</td>
<td>Knowledge sharing and communication - effect of reducing information asymmetry.</td>
</tr>
<tr>
<td>What is the benefit of client knowledge sharing?</td>
<td>Contributes to a: Collaborative, Respectful, Professional and, Trusting relationship.</td>
</tr>
<tr>
<td>What would you describe as being uncertainty consciousness?</td>
<td>A viewpoint that continuously examines how uncertainty may occur and what the effect would be.</td>
</tr>
<tr>
<td>What would you say is the upside of uncertainty?</td>
<td>Opportunities embedded in uncertainty</td>
</tr>
<tr>
<td>How is uncertainty managed?</td>
<td>Supportive uncertainty management culture in the EPCM and client groups, Collaborative, respectful, professional and trusting relationship, Uncertainty management and culture, Uncertainty information sharing, Uncertainty control mechanism, Systematic assessment of uncertainties.</td>
</tr>
<tr>
<td>How would you describe the EPCM uncertainty management maturity?</td>
<td>Process - management planning, identification, analysis and response, Application, Experience, Culture.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>How can flexible strategies (options) in this realm assist in conditions of uncertainty?</td>
<td>Develops options: flexibility and generativity</td>
</tr>
</tbody>
</table>
| How can an effective uncertainty management program benefit the project? | • Cost control,  
• Program,  
• Client satisfaction,  
• Limitation of rework. |
| How would you measure uncertainty? | • Aggregate uncertainty,  
• Weighted aggregate uncertainty,  
• Deviation uncertainty. |
| What would you understand by the term WBS granularity? | Excessive breakdown creates complexity with little benefit regarding the reporting of the project |
| How would you manage design activities in period of uncertainty? | Postpone critical decisions until as late as possible to reduce as much as possible the effect of uncertainty on the outcomes |

### 5.4.5 Project gaps

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you understand as being a project gap?</td>
<td>Place minimisation of client surprise at the heart of the assessment of project success.</td>
</tr>
</tbody>
</table>
| What would you consider to be a gap? | • Between customer expectation and the perception of those expectations,  
• Between the perception of those expectations and the translation of those expectations into specifications,  
• Between specification and actual delivery,  
• Between the delivery and the communication to the client,  
• Between the delivery and the client's perception of the delivery. |
| What were the instigators of project gaps? | • Tools and techniques rather than strategic aspects,  
• Failure to theorise on managing temporary teams,  
• Inherently bureaucratic,  
• Maladapted to the dynamic, complex environment of contemporary EPCM Companies,  
• Not focused on the needs of the client. |
| How do you prevent gaps from appearing? | Information flow and communication particularly in inherently innovative projects |
| How does the information flow vary during the execution of the project? | • Upstream - exploration of options,  
• Intermediate - choose clearly and decisively, freezing the design,  
• Realisation - mobilise as quickly as possible, significant financial investment. |

### 5.4.6 Project crisis

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| What would you view as being a project crisis? Example? | • Valuable events where learning aspects can be found,  
• A crisis is a terrible thing to waste. |
<p>| What opportunities does a crisis present? | |</p>
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What reduces the likelihood of a project crisis?</td>
<td>More complete project definition</td>
</tr>
</tbody>
</table>
| How can the effect of a project crisis be mitigated? | • Mobilisation,  
• Prioritisation,  
• Normalisation,  
• Responsibility. |
| What practices can be instituted/instilled? | • Initial call,  
• Maintenance of calm,  
• Assessment of the situation,  
• Assignment of responsibility,  
• Temporary permanency,  
• Response teams and debriefing. |
| What is the crisis philosophy? | A crisis only becomes a crisis when it is allowed to become a crisis. |

5.4.7 Project failure

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would you say are the determinants of project failure?</td>
<td>Under developed human systems</td>
</tr>
</tbody>
</table>
| What are the non-technical failure indicators? | • Designer not retained to conduct inspections,  
• Lack of access to the client,  
• Designer not responsive to complaints,  
• Assumptions not documented,  
• Not managing QA tasks,  
• Inadequate fee budgets,  
• Design technology above client staff,  
• Lack of access to client staff,  
• Project team members not having worked together,  
• Designer acceding to client’s direction. |
| What are the contributing causes to project failure? | • Recommendations not followed by the client/contractor,  
• Lack of disclosure or risks, uncertainties and consequences,  
• Technical errors or omissions,  
• Limited scope of work,  
• Inadequate documentation,  
• Lack of training,  
• Breakdown in communication. |
| What would you say are the failure contributors? | • Poor planning,  
• Poor estimates, lack of data and or time,  
• Lack of data for planning,  
• Planning haphazard,  
• Poor communication of objectives,  
• Personnel not available, poor retention of key skills,  
• Poor reporting,  
• Lack of specification control,  
• Poor work consistency,  
• Poor risk management,  
• Poor change management,  
• Details overlooked,  
• Too ambitious. |
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What role does the project manager play in project failure?</td>
<td>• Poor skills,</td>
</tr>
<tr>
<td></td>
<td>• Poor application of skills.</td>
</tr>
<tr>
<td>What short cuts contribute to project failure?</td>
<td>Short cuts:</td>
</tr>
<tr>
<td></td>
<td>• No peer review,</td>
</tr>
<tr>
<td></td>
<td>• Close configuration management,</td>
</tr>
<tr>
<td></td>
<td>• Omitting risk management.</td>
</tr>
<tr>
<td>What role does program management and planning play in project failure?</td>
<td>• Reluctance to carry out detailed planning,</td>
</tr>
<tr>
<td></td>
<td>• Real complexities are modified and simplified to fit the software available.</td>
</tr>
<tr>
<td>What role does changes of objectives and requirements play in project failure?</td>
<td>Have outgrown the capabilities of the analytical software.</td>
</tr>
<tr>
<td>What role does project complexity and global distribution play in project failure?</td>
<td>Have outgrown the capabilities of the analytical software.</td>
</tr>
<tr>
<td>What remedial actions could prevent project failure?</td>
<td>• Diligent application of project management procedures,</td>
</tr>
<tr>
<td></td>
<td>• Well qualified project manager,</td>
</tr>
<tr>
<td></td>
<td>• Accurate definition of the tasks at hand,</td>
</tr>
<tr>
<td></td>
<td>• Right sized project work packages,</td>
</tr>
<tr>
<td></td>
<td>• Network planning techniques,</td>
</tr>
<tr>
<td></td>
<td>• Realistic information flow,</td>
</tr>
<tr>
<td></td>
<td>• Prepared to re-plan jobs to accommodate changes,</td>
</tr>
<tr>
<td></td>
<td>• Record and apply lessons learnt.</td>
</tr>
<tr>
<td>What do you understand by tipping point failures in projects?</td>
<td></td>
</tr>
<tr>
<td>How do tipping point failures manifest themselves?</td>
<td>Progress slowing, stopping or even turning negative.</td>
</tr>
<tr>
<td>What would you say are the drivers for tipping point failures?</td>
<td>Initial completion backlog, QA backlog, additional work and rework.</td>
</tr>
<tr>
<td>What would you say are biases that contribute to project failure?</td>
<td>• Lack of reference data,</td>
</tr>
<tr>
<td></td>
<td>• Excessive conservatism,</td>
</tr>
<tr>
<td></td>
<td>• Over commitment of resources,</td>
</tr>
<tr>
<td></td>
<td>• Group think,</td>
</tr>
<tr>
<td></td>
<td>• Illusion of control,</td>
</tr>
<tr>
<td></td>
<td>• Overconfidence,</td>
</tr>
<tr>
<td></td>
<td>• Recency,</td>
</tr>
<tr>
<td></td>
<td>• Selective perception,</td>
</tr>
<tr>
<td></td>
<td>• Sunk cost trap.</td>
</tr>
<tr>
<td>What project culture would mitigate the propensity for project failure?</td>
<td>• Open culture (Boeing 777),</td>
</tr>
<tr>
<td></td>
<td>• Reduced fear of failure (Merck).</td>
</tr>
<tr>
<td>What effect would the regulatory environment have on the delivery of projects?</td>
<td></td>
</tr>
<tr>
<td>How are ‘project failure’ learning points captured into the company learning?</td>
<td>After action review,</td>
</tr>
<tr>
<td></td>
<td>Lessons learnt review.</td>
</tr>
<tr>
<td>How do individual stakeholder objectives affect the project outcomes?</td>
<td>Stakeholders behave in ways in which they fell will help them accomplish their project objectives - these may or not be congruent with the project objectives</td>
</tr>
</tbody>
</table>
### Aspect | Discussion
--- | ---
What effect does poor planning have on project outcomes? | Delusions or honest mistakes, Deceptions or strategic manipulation of information, Bad luck, Scope change, High complexity.
What would you say are the main categories of project planning errors? | The completed project has to deliver value to the organisation
Would a greater operational link for the project reduce the propensity for project failure? | Delusions or honest mistakes, Deceptions or strategic manipulation of information, Bad luck, Scope change, High complexity.

### 5.4.8 Project success

| Aspect | Discussion |
--- | --- |
What defines the success of your project? | Client or the EPCM Company definitions. |
How is the project success measured and displayed? | Balanced score card: technical, financial, human elements. |
Has your project suffered from a disrupted program? | Cancellation or delay to execution, Scope increase or reduction from the client, Delays in receipt of materials, Change in main project client. |
What was the nature of this disruption? | Adequate resources, Support from top management, Mutual trust, Long term commitment, Effective communication, Efficient coordination, Productive conflict resolution. |
How can success be better assured in project partnerships? | Too general, lack specific guidelines |
Are the 'critical success factors' an assistance to decision making? | Activity definition, Schedule development, Project plan development, Cost budgeting, Activity sequencing, Scope definition, Cost estimating. |
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would you say are key contributors to success in an International environment?</td>
<td>• Examine and prioritise your motives and strategic objectives,</td>
</tr>
<tr>
<td></td>
<td>• Select compatible partner organisations,</td>
</tr>
<tr>
<td></td>
<td>• Clear goals and targets,</td>
</tr>
<tr>
<td></td>
<td>• Realistic objectives and performance targets,</td>
</tr>
<tr>
<td></td>
<td>• Clear governance mechanisms and roles,</td>
</tr>
<tr>
<td></td>
<td>• Consult and build consensus,</td>
</tr>
<tr>
<td></td>
<td>• Commitment of senior management,</td>
</tr>
<tr>
<td></td>
<td>• Constant assessment of socio political and economic environment,</td>
</tr>
<tr>
<td></td>
<td>• Cultural sensitivity,</td>
</tr>
<tr>
<td></td>
<td>• Trust until proven wrong.</td>
</tr>
</tbody>
</table>

**5.4.9 Conflict management**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has there been any conflict during the execution of your project?</td>
<td>Construction exists within an adversarial environment.</td>
</tr>
<tr>
<td>What was the nature of this conflict in a project environment?</td>
<td></td>
</tr>
<tr>
<td>What are the main causes of conflict in a project environment?</td>
<td>Prevention - minimise sources of conflict</td>
</tr>
<tr>
<td></td>
<td>Negotiation - discuss differences in meetings</td>
</tr>
<tr>
<td></td>
<td>Standing neutral - objective and unbiased</td>
</tr>
<tr>
<td>How do you minimise the sources of conflict in a project environment?</td>
<td></td>
</tr>
<tr>
<td>What are the detrimental effects of conflict in a project environment?</td>
<td>Project disruptions</td>
</tr>
<tr>
<td></td>
<td>Cost of litigation</td>
</tr>
<tr>
<td>What are the positive effects of conflict in a project environment?</td>
<td></td>
</tr>
<tr>
<td>How would you resolve conflict between two parties?</td>
<td></td>
</tr>
<tr>
<td>How would you arrive at a resolution?</td>
<td>• Non-binding resolution,</td>
</tr>
<tr>
<td></td>
<td>• Binding resolution,</td>
</tr>
<tr>
<td></td>
<td>• Litigation.</td>
</tr>
<tr>
<td>What could be source of conflict in a global project in the design phase?</td>
<td>• Information gathering techniques,</td>
</tr>
<tr>
<td></td>
<td>• Aesthetic views,</td>
</tr>
<tr>
<td></td>
<td>• Drawing standards,</td>
</tr>
<tr>
<td></td>
<td>• Construction materials,</td>
</tr>
<tr>
<td></td>
<td>• Technological and organisational complexity,</td>
</tr>
<tr>
<td></td>
<td>• Cross boarder contracting of work packages.</td>
</tr>
<tr>
<td>What could be source of conflict in a global project in the construction phase?</td>
<td>• Regional material availability,</td>
</tr>
<tr>
<td></td>
<td>• Complex coordination,</td>
</tr>
<tr>
<td></td>
<td>• Contracting practices,</td>
</tr>
<tr>
<td></td>
<td>• Regulations and documentation.</td>
</tr>
<tr>
<td>How would you manage conflict in a global project?</td>
<td>Could result in high costs</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>What is the influence and effect of global procurement on project failure?</td>
<td></td>
</tr>
</tbody>
</table>

### 5.4.10 Project management philosophy

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why do you think project management principles have become widespread in industry?</td>
<td></td>
</tr>
<tr>
<td>Why do mining projects generally have significant overrun on costs and schedule?</td>
<td></td>
</tr>
<tr>
<td>Is the PMBoK® way fully applicable to long term mining projects?</td>
<td></td>
</tr>
</tbody>
</table>

### 5.4.11 Last planner

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What detail of planning is in place at the start of the project?</td>
<td>Chain of planners, last planners adds the final detail prior to execution.</td>
</tr>
<tr>
<td>What time planning horizon do you look at?</td>
<td>Work should not start until all the items required for completion are available. Move from the Can to Will category.</td>
</tr>
<tr>
<td>Do you have a buffer of tasks for the design or construction crews?</td>
<td>Structured weekly dispatching procedure.</td>
</tr>
<tr>
<td>How do you monitor the task completion performance on your project?</td>
<td></td>
</tr>
<tr>
<td>How does the ‘Last Planner’ facilitate the project?</td>
<td>Focus on plan realisation. Flow and transformation in short term planning, execution and control.</td>
</tr>
</tbody>
</table>

### 5.4.12 Agile project management

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your definition of a project?</td>
<td>Discontinuous, exceptional and unrepeated actions.</td>
</tr>
<tr>
<td>What would you understand by the term ‘agile project management’?</td>
<td>Improvisational project management.</td>
</tr>
<tr>
<td>What would you see as being the advantages of agile project management?</td>
<td>Turbulent environment, the need to survive, completing the project in iterations thus reducing and eliminating uncertainty. Flexibility to adjust to changes. Appropriate for complex, uncertain and heavily time constrained project environments.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>What would be the requirements for implementing agile project management</td>
<td>• Adaptive project management team,</td>
</tr>
<tr>
<td></td>
<td>• Adaptive organisation.</td>
</tr>
<tr>
<td>When would the use of agile project management tactics be advantageous?</td>
<td>The need to:</td>
</tr>
<tr>
<td></td>
<td>• effect change,</td>
</tr>
<tr>
<td></td>
<td>• alter strategic direction,</td>
</tr>
<tr>
<td></td>
<td>• take advantage of new or emerging opportunities.</td>
</tr>
<tr>
<td>What would be the basic tools of agile project management?</td>
<td>• Creativity,</td>
</tr>
<tr>
<td></td>
<td>• Intuition,</td>
</tr>
<tr>
<td></td>
<td>• Tacit knowledge.</td>
</tr>
<tr>
<td>Why would improvisation be a prerequisite?</td>
<td>Intuitive feel for an executable solution.</td>
</tr>
<tr>
<td>What would be the role of improvisation in project management?</td>
<td></td>
</tr>
<tr>
<td>What would you see as being the challenges of agile project management?</td>
<td>Not suited to dispersed project teams. Though can be applied locally to teams. Greater commitment from the team members</td>
</tr>
</tbody>
</table>

### 5.4.13 Project systems

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the company adopt project management principles throughout the entire company?</td>
<td>Does this include departments such as:</td>
</tr>
<tr>
<td></td>
<td>• Payroll,</td>
</tr>
<tr>
<td></td>
<td>• Human resources,</td>
</tr>
<tr>
<td></td>
<td>• Procurement.</td>
</tr>
<tr>
<td>What would be the benefits of the EPCM Company embracing a project management methodology in all aspects of the business?</td>
<td>Engender a greater understanding of the operational challenges throughout the company.</td>
</tr>
</tbody>
</table>

### 5.4.14 Project control in uncertain environments

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would you define project uncertainty?</td>
<td></td>
</tr>
<tr>
<td>Ambiguity is seen to be a cause of uncertainty, what do you see as the drivers of uncertainty?</td>
<td>• Information load - ambiguous data,</td>
</tr>
<tr>
<td></td>
<td>• Complexity - initiating selectivity,</td>
</tr>
<tr>
<td></td>
<td>• Turbulence - instability and randomness.</td>
</tr>
<tr>
<td>How would uncertainty affect the decision making process within the project?</td>
<td></td>
</tr>
<tr>
<td>Is the traditional matrix environment appropriate in an uncertain and turbulent environment?</td>
<td></td>
</tr>
<tr>
<td>How does senior management respond to increasing levels of uncertainty?</td>
<td></td>
</tr>
</tbody>
</table>
### 5.4.15 Managing multiple projects

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would you describe a multiple project environment?</td>
<td></td>
</tr>
<tr>
<td>What challenges does running multiple projects present?</td>
<td>• Multiple interfaces with projects and operations,</td>
</tr>
<tr>
<td></td>
<td>• Resource sharing, information competition,</td>
</tr>
<tr>
<td></td>
<td>• Prioritising resources,</td>
</tr>
<tr>
<td></td>
<td>• Delivery of related objectives.</td>
</tr>
<tr>
<td>What are the problems related to managing multiple projects?</td>
<td>• Coordination of the portfolio - portfolio planning cycle,</td>
</tr>
<tr>
<td></td>
<td>• Reduced learning and knowledge retention.</td>
</tr>
<tr>
<td>How does the company structure support managing multiple projects?</td>
<td>• Matrix structure - confusion over roles and responsibilities between function and project managers,</td>
</tr>
<tr>
<td></td>
<td>• Unsuitable reporting and reward systems,</td>
</tr>
<tr>
<td></td>
<td>• Assignment of scarce resources,</td>
</tr>
<tr>
<td></td>
<td>• Ambiguity induces motivation and job satisfaction,</td>
</tr>
<tr>
<td></td>
<td>• Poor communication.</td>
</tr>
<tr>
<td>What are the key aspects for companies managing multiple projects?</td>
<td>• Alignment management,</td>
</tr>
<tr>
<td></td>
<td>• Communication and control,</td>
</tr>
<tr>
<td></td>
<td>• Effective learning and knowledge management systems.</td>
</tr>
</tbody>
</table>

### 5.4.16 Relational contracting

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you understand by the term relational contracting in a project</td>
<td>Value placed on future business, informal agreements based on the value of future business</td>
</tr>
<tr>
<td>environment?</td>
<td></td>
</tr>
<tr>
<td>What is the value of relational contracting in a project environment?</td>
<td></td>
</tr>
<tr>
<td>How would you interpret relational employment in a project environment?</td>
<td></td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>How would you interpret relational outsourcing in a project environment?</td>
<td></td>
</tr>
</tbody>
</table>

### 5.4.17 Fast-tracking

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your interpretation of the term fast tracking?</td>
<td></td>
</tr>
<tr>
<td>Compression of timelines and the overlapping of project activities.</td>
<td></td>
</tr>
<tr>
<td>Why are projects fast-tracked? What are the benefits of fast tracking?</td>
<td></td>
</tr>
<tr>
<td>• To bring the revenues closer to the present,</td>
<td></td>
</tr>
<tr>
<td>• Uncertainty,</td>
<td></td>
</tr>
<tr>
<td>• Economic uncertainty,</td>
<td></td>
</tr>
<tr>
<td>• Social and political uncertainty,</td>
<td></td>
</tr>
<tr>
<td>• Reduced inflation and interest costs,</td>
<td></td>
</tr>
<tr>
<td>• Market competition,</td>
<td></td>
</tr>
<tr>
<td>• Market commitments.</td>
<td></td>
</tr>
<tr>
<td>What risks does fast tracking induce in the project?</td>
<td></td>
</tr>
<tr>
<td>• Scheduling,</td>
<td></td>
</tr>
<tr>
<td>• Logistics,</td>
<td></td>
</tr>
<tr>
<td>• Cost increases.</td>
<td></td>
</tr>
<tr>
<td>How would you attain early revenues?</td>
<td></td>
</tr>
<tr>
<td>Utilisation of permanent plant during the project execution.</td>
<td></td>
</tr>
</tbody>
</table>

### 5.4.18 Large multidiscipline mining (LMM) projects

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would you define an LMM project?</td>
<td></td>
</tr>
<tr>
<td>• High capital cost,</td>
<td></td>
</tr>
<tr>
<td>• Long duration but program urgency,</td>
<td></td>
</tr>
<tr>
<td>• Technologically demanding,</td>
<td></td>
</tr>
<tr>
<td>• Logistically demanding,</td>
<td></td>
</tr>
<tr>
<td>• Multidiscipline,</td>
<td></td>
</tr>
<tr>
<td>• Many organisations participating (virtual environment).</td>
<td></td>
</tr>
<tr>
<td>How do you see the future of the LMM project?</td>
<td></td>
</tr>
<tr>
<td>What are the pressures resulting from LMM projects?</td>
<td></td>
</tr>
<tr>
<td>• Market competitiveness,</td>
<td></td>
</tr>
<tr>
<td>• Productivity,</td>
<td></td>
</tr>
<tr>
<td>• Client satisfaction.</td>
<td></td>
</tr>
<tr>
<td>What are the challenges of LMM projects in the virtual project house?</td>
<td></td>
</tr>
<tr>
<td>Lack of understanding of the client’s requirements.</td>
<td></td>
</tr>
<tr>
<td>What are the favourable trends in LMM projects?</td>
<td></td>
</tr>
<tr>
<td>• More risk to the contractor,</td>
<td></td>
</tr>
<tr>
<td>• More technical input from the contractor,</td>
<td></td>
</tr>
<tr>
<td>• Contractor risk,</td>
<td></td>
</tr>
<tr>
<td>• Risk - reward balance shifting,</td>
<td></td>
</tr>
<tr>
<td>• Client outsourcing of all non-core activities,</td>
<td></td>
</tr>
<tr>
<td>• Sharing lessons and knowledge,</td>
<td></td>
</tr>
<tr>
<td>• Electronic document shifting, volume of information swapped,</td>
<td></td>
</tr>
<tr>
<td>• Project cycle reduction,</td>
<td></td>
</tr>
<tr>
<td>• Shift to strategic alliances and integrated supply chains.</td>
<td></td>
</tr>
</tbody>
</table>
### 5.4.19 Project safeguards

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you understand as being a project safeguard?</td>
<td></td>
</tr>
<tr>
<td>Why would a project safeguard be required?</td>
<td></td>
</tr>
<tr>
<td>What would be an example of a project safeguard?</td>
<td>• Growth capacity,</td>
</tr>
<tr>
<td></td>
<td>• Phased development,</td>
</tr>
<tr>
<td></td>
<td>• Changes in the operating regime,</td>
</tr>
<tr>
<td></td>
<td>• Energy conservation,</td>
</tr>
<tr>
<td></td>
<td>• Water conservation,</td>
</tr>
<tr>
<td></td>
<td>• Preventing premature future obsolescence.</td>
</tr>
<tr>
<td>What would be an example of a mining project safeguard?</td>
<td>Scope for increased capacity</td>
</tr>
<tr>
<td></td>
<td>Terrace allocation to expansion beyond the defined project lease area</td>
</tr>
</tbody>
</table>

### 5.4.20 Estimating

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would you say are the challenges presented by estimating on a ‘Mega Project’?</td>
<td>• The complexity and scale of the project,</td>
</tr>
<tr>
<td></td>
<td>• The size of the tender list required for the estimate.</td>
</tr>
<tr>
<td>What would you say makes for successful estimating?</td>
<td>• Anticipation,</td>
</tr>
<tr>
<td></td>
<td>• Organising, planning,</td>
</tr>
<tr>
<td></td>
<td>• Well organised (roles and responsibilities) and focused team,</td>
</tr>
<tr>
<td></td>
<td>• Experienced team members,</td>
</tr>
<tr>
<td></td>
<td>• Good assumptions and sound industry norms.</td>
</tr>
<tr>
<td>What effect can the surfeit of projects have on the estimating process?</td>
<td>• Saturated market,</td>
</tr>
<tr>
<td></td>
<td>• Price increases (steel/ cement prices and availability),</td>
</tr>
<tr>
<td></td>
<td>• Overseas procurement.</td>
</tr>
<tr>
<td>What responses can be expected from the vendors?</td>
<td>• Vendor fatigue,</td>
</tr>
<tr>
<td></td>
<td>• Reduced propensity to tender.</td>
</tr>
<tr>
<td>Where are the sources of bias and error in estimating?</td>
<td>• Absence of learning on the part of the sponsor,</td>
</tr>
<tr>
<td></td>
<td>• Absence of learning on the part of the EPCM Company.</td>
</tr>
<tr>
<td>What is the effect of cost overruns on the project execution?</td>
<td></td>
</tr>
<tr>
<td>Why would you say there is a trend to underestimate during the feasibility study?</td>
<td>• Projects come out 14% higher than as estimated in the BFS,</td>
</tr>
<tr>
<td></td>
<td>• Deliberate deception,</td>
</tr>
<tr>
<td></td>
<td>• Incentives to underestimate the capital costs,</td>
</tr>
<tr>
<td></td>
<td>• Excess demand for financing in the mining industry,</td>
</tr>
<tr>
<td></td>
<td>• The need to give the project a good representation.</td>
</tr>
<tr>
<td>Why would underestimation persist?</td>
<td>• Information asymmetry,</td>
</tr>
<tr>
<td></td>
<td>• Learning barriers,</td>
</tr>
<tr>
<td></td>
<td>• Poor coordination.</td>
</tr>
<tr>
<td>What do you understand of the term information asymmetry?</td>
<td>Engineering consultant and the project sponsor have more and better information than the project financiers</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| Is cost underestimation prevalent in both small and large projects? | • Big mining houses have less competition for financing,  
• Smaller projects are subject to less scrutiny. |
| How can ‘cognisant’ cost overruns be mitigated? | • Intentional with implicit agreement from the project sponsors (client),  
• Experience. |
| Would you say that project returns are similarly biased? | |
| Would you say that project risks are misrepresented? | |

### 5.4.21 Forethought

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| Do you have open team discussions during the CBE phase of the project? | • Project premortem,  
• Vocalising reservations in an open environment,  
• Allowing dissenters to vocalise reservations. |
| Do you identify people who are ‘overinvested’ in the project? | Pre-empting biases |
| How would you identify potential project failings at the earliest opportunity? | |

### 5.4.22 Project risk

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you define risk?</td>
<td>The possibility that events, their resulting impacts and dynamic interactions may turn out differently than anticipated</td>
</tr>
</tbody>
</table>
| What would be the basic principle of risk management? | Improving the value of decision making  
Evaluating changes to cost and duration parameters  
Evaluating consequences and possibilities |
| What do you see as being the principle risks on your project? | |
| What is the best time to address project risks? | • Early in the project planning phase to enable the adequate planning of responses. |
| What would you see as being the two principle sources of risk? | • Natural,  
• Human. |
| In the team gathering process what would say are the challenges? | • Assembling the team,  
• Managing the team,  
• Absorbing the cost. |
| What would be the principle human risks? | Knowledge gaps; gap between what we should know and what we really know |
| How should knowledge gaps be addressed? | • Better to be proactive than reactive,  
• Different design approach and different technology,  
• Different technology partner,  
• Past experience. |
| What would you describe as being operational risks? | • Leadership failure,  
• Contractor/ supplier failure,  
• Technical complexities. |
<table>
<thead>
<tr>
<th><strong>Aspect</strong></th>
<th><strong>Discussion</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you evaluate business risks as well as operational risks?</td>
<td></td>
</tr>
<tr>
<td>In the risk analysis process are internal and external risks contemplated?</td>
<td>The pathogen construct - internal risks are insidious risks resident within the project team</td>
</tr>
<tr>
<td>What are the basic steps you follow in the risk analysis process?</td>
<td>Identification, Estimation, Analysis and evaluation.</td>
</tr>
<tr>
<td>Can you be certain that all risks are identified in the initial risk management processes?</td>
<td></td>
</tr>
<tr>
<td>What would you say are your project's five principle risks?</td>
<td></td>
</tr>
<tr>
<td>What are the sources of these risks?</td>
<td></td>
</tr>
<tr>
<td>Who is the best party to manage or take ownership of these risks?</td>
<td>Client, Contractor, Shared.</td>
</tr>
<tr>
<td>What role does communication play in the risks management process?</td>
<td></td>
</tr>
<tr>
<td>In project execution what would be the principle risks facing the large scale project?</td>
<td>Shortage of resources in the developer's team</td>
</tr>
<tr>
<td>Are the conventional risk management processes appropriate for large scale projects?</td>
<td>Previous project databases can be in appropriate, Allocating contingency budgets can be ineffective, A wider perspective needs to be adopted.</td>
</tr>
<tr>
<td>For large scale projects would it be more appropriate to be proactive as opposed to being reactive?</td>
<td>Risk management becomes a daily activity rather than the implementation of a pre-determined risk management plan - agile risk management</td>
</tr>
<tr>
<td>What new risks are introduced by managing a portfolio of projects?</td>
<td>Expanded focus and requirements, Clear links to operational objectives, Interrelations between the projects.</td>
</tr>
<tr>
<td>Is the current risk management process suited to managing the portfolio of projects?</td>
<td>The links between the projects are not established, Functional risk is not evaluated, Project issues between the projects must be evaluated, All the issues should be applied to all of the projects.</td>
</tr>
<tr>
<td>What would you describe as being intuitive risk management?</td>
<td>Risk identification through experience</td>
</tr>
<tr>
<td>What new risks can sub-contractors introduce?</td>
<td>Relational risks in the dynamic project network, Relationships with other sub-contractors, client, competitors and local bodies.</td>
</tr>
<tr>
<td>Are all risks manageable?</td>
<td></td>
</tr>
<tr>
<td>Are all risks managed?</td>
<td></td>
</tr>
<tr>
<td>Are all risks declared at the inception of the project?</td>
<td>Asymmetric information</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
</tr>
</tbody>
</table>
| How would you categorise risks? | • All risks to be known,  
• Risks prioritised,  
• Risks bundled,  
• Broken down to hierarchy,  
• Relationships captures,  
• Evolution modelled. |
| Are some risks ignored? |  |
| Why could some risks be ignored? | Perceived effect on project delivery, the ability to deliver on time and on budget |
| Are you aware of all the risks present in your project? |  |
| Is all risk evaluation and risk management satisfactory? |  |
| Does your client apply an early design commitment strategy? | Upside risk of speeding up delivery  
Downside risk of design rework |
| Why is this applied? |  |
| Is it successful? |  |
| What about late changes to the project definition? |  |
| Do you practice design postponement to as late as possible to minimise risk? | Reduces expected variability in the design  
Necessity to be able to foresee uncertainties |
| What factors affect the client’s decision to expedite the design process? | Rush and be wrong or wait and be late |
| To what extent is concurrent engineering practiced? |  |
| What risks are induced by the EPCM Company and Client processes? | Communication risk,  
External risk,  
Financial risk,  
Location risk,  
Organisation risk,  
Resource risk,  
Schedule risk,  
Technical risk. |
| What are the project specific challenges relating to concurrent engineering? | Interdependencies not realised from the outset, uncertainty,  
Scheduling complexities. |
| What would you say are the risks introduced by globalisation? | Uncertainty,  
Communication. |
| Have you considered using a risk breakdown structure? | Structure the risks,  
Grouping of risks,  
Prioritise holistically,  
Identify the nature of the risk,  
The ability to roll up and roll down for insight to risk exposure,  
Cross project reporting,  
Lessons learnt. |
| Are the risks on your project affecting the business clearly understood by all on the project | Risk identification,  
Risk assessment,  
Risk reporting. |
## 5.4.23 Project sponsorship

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would you say is the role of the project sponsor?</td>
<td>The executive with an interest in the project.</td>
</tr>
</tbody>
</table>
| What would you say are the beneficial attributes of a project sponsor? | • Appropriate seniority,  
• Political knowledge,  
• Connections  
• Take on the organisation,  
• Motivation - deliver the vision, provide support,  
• Partner with the project manager and the team,  
• Excellent communication skills,  
• Compatible personality,  
• Provide objectivity and challenge the project. |
| How does this role differ between the Client sponsor and the EPCM Company sponsor? | |
| What would you say are the key behaviours of the project sponsor? | • Ensure planning,  
• Clarify outputs,  
• Oversee stakeholder relationships,  
• Support the project,  
• Appoint the correct project manager. |
| What would you say would be successful outcomes for the project sponsor? | • Meeting agreements,  
• Customer success (high level),  
• Assuring the EPCM Company future. |
| What would you say would be detrimental sponsor behaviours? | |
| How should the project sponsor behave during the execution of the project? | • Allow the project team to execute the project,  
• Front end loading of the project into the company structure. |
| What would you say are the principle project sponsor failings? | • Lack of project ownership,  
• Insufficient project engagement,  
• Lack of high level support,  
• Lack of tolerance for ambiguity (projects with complexity and risk). |
| How would you overcome inadequate project sponsorship? | |
| What would you say are the challenges facing the project sponsor in the EPCM Company environment? | |

## 5.4.24 Communication

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| What are the fundamental drivers of project communication? | • Guides and coordinated ongoing activities,  
• Translates and reduces information,  
• Creates space for the experience of contractors,  
• Coordinates unexpected situations. |
<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| How did you establish your communication strategy?                   | • Identify stakeholders,  
  • Prioritise,  
  • Map the stakeholder community,  
  • Develop communication targets,  
  • Monitor communication effectiveness. |
| What are the negative effects of poor communication?                  | • Confusion among the participants,  
  • Misunderstandings,  
  • Increased costs,  
  • Project failure. |
| Is all communication on your project formal?                          |                                                                                                                                          |
| What is the value of informal communication?                         | In uncertain and complex environments there is a shift to informal communication.                                                          |
| Who is responsible for the communication on the project?             | Project liaison officer. Reduction and translation of information.                                                                          |
| What is the root cause of the proliferation of asymmetric information? | Attention has to be paid to where information imbalances occur.                                                                            |
| What is your interpretation of asymmetric information?               | Where one of the two cooperating partners is better informed.                                                                                |
| What are the possible effects of asymmetric information?              | Possible lee-ways have to be identified and addressed during the execution of the project.  
  • Economic disadvantages,  
  • Inefficient use of resources,  
  • Losses of welfare,  
  • Poor selection of contractors. |
| How can asymmetric information be compensated for?                   | Transparent communication systems. Efficient reporting systems.                                                                            |
| What are the advantages of a competent communication system?          | • Responsibility transparency,  
  • Effective eMail communication,  
  • 24hour overview of the project status,  
  • Versatility of information interrogation,  
  • Managed expectations and the closing of gaps. |
| What are the challenges confronting effective communication?           | • Multiple lines of authority,  
  • Virtual teams,  
  • Changing scope,  
  • Many levels of authority,  
  • Balance. |
| How can communication be used to manage the client perceptions?       |                                                                                                                                          |

**5.4.25 Project close-out**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the execution of the project are life-cycle costs considered?</td>
<td></td>
</tr>
<tr>
<td>What post project completion changes have been executed on your project?</td>
<td></td>
</tr>
</tbody>
</table>
| What are the root causes of post project changes?                    | • Early design freeze?  
  • Inexperienced client? |

---

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<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
</table>
| What post project changes are taking place? | • Operational changes,  
• Safety changes,  
• Aesthetics or ergonomics,  
• Uncontrolled changes,  
• Financial driven changes. |
| What are the effects of changes in a project? | Negative and positive                                                     |
| What are the main causes of post project changes? | • Engineering oversight,  
• Users unaware of need,  
• New user demand,  
• External changes,  
• Operational conditions,  
• Realisation of operations,  
• Politics. |
| What can be done to reduce or mitigate post project completion changes? | • Client involvement,  
• Improved engineering,  
• Flexible execution model,  
• Flexible design model,  
• Reviewing future needs. |

5.4.26 Concluding comments

Thank you for your participation in this survey and for the response to the questions. Your cooperation is greatly valued and your responses will add value to the completed study. This information will be captured and evaluated. The comparison to best practices and the modification to best practices in this environment will add greatly to the value the company can give to the client and the value that can be created within the company.

5.5 Interviews

5.5.1 Research ethics note

From Saunders, Lewis and Thornhill (2000: 132) and Zikmund (2002: 77) the following interviews were conducted under the following circumstances and conditions to assure the efficacy of the results and to assure the anonymity of the respondents:

- Consent to participate was obtained from the interviewee,
- The intent of the study was discussed as was the form in which the results would be presented,
- The privacy and anonymity of the respondents was assured,
- The involvement was voluntary and at any time during the process the respondents could halt the proceedings or refuse to answer any question,
• The interviews were objective and the responses carefully noted and/ or transcribed.

• In addition, the following aspects were maintained:
  o There was a right not to participate,
  o The responses were voluntary and obtained from senior personnel,
  o The interviews were conducted in an office environment during normal working hours at a time determined by the respondent,
  o Where the interviewees were based on remote sites, or would only be available for a brief period consent was given for the interviewee to complete the question responses in their own time,
  o The questions were probing but were answered in the own words of the respondent,
  o The interviewees were encouraged to reflect on their own practices and opinions,

• At the conclusion of the interview the respondent was thanked and the process followed was summarised and the confidentiality of the information gathered was assured.

5.5.2 Interviewee environment

All of the EPCM interviewees were employed by a large multidisciplinary project management company. All of the interviewees were engaged in the execution of large multidisciplinary mining projects for this company. One interviewee was employed by a mining company.

One of the interview results is included here for information.

5.5.3 Interview one

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Global Director: Mining Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>53</td>
</tr>
<tr>
<td>Project experience</td>
<td>29 years</td>
</tr>
<tr>
<td>Project name</td>
<td>Impala 20 Shaft</td>
</tr>
<tr>
<td>Project description</td>
<td>EPCM Mining Projects</td>
</tr>
<tr>
<td>Project start</td>
<td>October 2005</td>
</tr>
<tr>
<td>Project duration</td>
<td>10 years</td>
</tr>
<tr>
<td>What project phase</td>
<td>Project Completion</td>
</tr>
<tr>
<td>are you currently in?</td>
<td></td>
</tr>
<tr>
<td>Project value</td>
<td>ZAR 5.6 billion</td>
</tr>
<tr>
<td>Note</td>
<td>All aspects discussed will be held in strictest confidence</td>
</tr>
</tbody>
</table>
## 5.5.3.1 Project leadership

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe your leadership style</td>
<td>Encourage the staff to take over the project.</td>
</tr>
<tr>
<td></td>
<td>Guidance and no detail.</td>
</tr>
<tr>
<td></td>
<td>Giving opportunities.</td>
</tr>
<tr>
<td>Is the same management style used for all situations</td>
<td>Varies depending on the seniority of the person.</td>
</tr>
<tr>
<td>and for all team-members?</td>
<td>Participative in the studies.</td>
</tr>
<tr>
<td></td>
<td>Communicative.</td>
</tr>
<tr>
<td>Has your project required a change in leadership</td>
<td>Phased approach from study to execution of the project.</td>
</tr>
<tr>
<td>style during execution?</td>
<td>Spends time on the construction of the team.</td>
</tr>
<tr>
<td>Does your leadership style positively influence</td>
<td>Without a doubt the management style has a distinct effect on the team</td>
</tr>
<tr>
<td>How would you say your leadership style has affected</td>
<td>The subordinates feel empowered and see opportunities to develop new skills.</td>
</tr>
<tr>
<td>the work performance of your subordinates?</td>
<td>Employees take ownership</td>
</tr>
<tr>
<td></td>
<td>Gain greater knowledge from the team members around them.</td>
</tr>
<tr>
<td>What skills should a project manager possess?</td>
<td>Underrated importance.</td>
</tr>
<tr>
<td></td>
<td>Should possess all skills: Scheduling, costing, communication, experience,</td>
</tr>
<tr>
<td></td>
<td>future sight to provide guidance and to understand who is struggling and</td>
</tr>
<tr>
<td></td>
<td>needs assistance when.</td>
</tr>
<tr>
<td></td>
<td>People management is the most important.</td>
</tr>
<tr>
<td>What selection criteria are used for Project</td>
<td>Project experience, product knowledge, education, communication skills.</td>
</tr>
<tr>
<td>Managers?</td>
<td></td>
</tr>
<tr>
<td>How do you deal with the internal (Company)</td>
<td>Reporting within the company administration structures.</td>
</tr>
<tr>
<td>administration?</td>
<td>Communication skills at all levels is important to afford the project the</td>
</tr>
<tr>
<td></td>
<td>correct support at various levels in the organisation.</td>
</tr>
<tr>
<td>On what criteria should a Project Manager be</td>
<td>Project performance: Costs, Time and safety.</td>
</tr>
<tr>
<td>evaluated?</td>
<td>Early communication.</td>
</tr>
</tbody>
</table>

## 5.5.3.2 Human resources and knowledge management

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the company have knowledge processes?</td>
<td>Lessons learnt processes often poorly applied and poorly retained even though they exist.</td>
</tr>
<tr>
<td></td>
<td>Relies mostly on experienced people within the structures of the company/project.</td>
</tr>
<tr>
<td></td>
<td>Engineering design packages are used to save/retrieve data from past designs making reliance on</td>
</tr>
<tr>
<td></td>
<td>individuals less important and making the company more cost competitive.</td>
</tr>
<tr>
<td>Do policies exist for Tacit and Explicit Knowledge</td>
<td>There are lessons learnt which are used for Risk Assessments and recently the whole project close</td>
</tr>
<tr>
<td>management?</td>
<td>out and reporting templates have been made available to PM's.</td>
</tr>
<tr>
<td></td>
<td>There are none existing within the old company.</td>
</tr>
<tr>
<td>Do policies for capturing knowledge exist?</td>
<td>Lessons learnt are captured and the Risk Department keeps a good data base as well as individual</td>
</tr>
<tr>
<td></td>
<td>departments such as Mineral Economics, Mining etc.</td>
</tr>
<tr>
<td></td>
<td>These need to be in a general data base accessible throughout the global offices.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Does tacit knowledge get captured into computer tools?</td>
<td>Often this achieved with the project close out report. This is generally poorly executed and becomes a time consuming exercise.</td>
</tr>
<tr>
<td>How do you encourage the divulgement of tacit knowledge?</td>
<td>This is through the lessons learnt register and should be done quarterly. This should not be used as a process to chastise the individual.</td>
</tr>
<tr>
<td>How do you manage knowledge gathering in environments of overload,</td>
<td>Facilitate the time required for knowledge collection even in times of distress and time pressurisation.</td>
</tr>
<tr>
<td>ambiguity and politics?</td>
<td></td>
</tr>
<tr>
<td>What is the strength of the engineering culture within your project/</td>
<td>Develop a can do attitude amongst the team members. Develop institutional knowledge amongst the senior members of the company and use these people as the go to people of the company.</td>
</tr>
<tr>
<td>company?</td>
<td></td>
</tr>
<tr>
<td>How is the ‘Engineering Culture’ modified to the benefit of the</td>
<td>Encouraging a low turnover of staff. Currently the staff turnover of staff is as low as 6% if not less.</td>
</tr>
<tr>
<td>project executables?</td>
<td></td>
</tr>
<tr>
<td>Is knowledge gathering always successful?</td>
<td>Knowledge management is not well managed and record of past project performance is difficult to retrieve. Often knowledge on past project performance has to be collect from the client. This has an obvious risk of perceptions being provided as project facts.</td>
</tr>
<tr>
<td>Is knowledge management a primary concern?</td>
<td>Very much so. For example, the client will often as for evidence of knowledge management as a potential deciding factor for EPCM selection. For example, Wafi Golpu greenfield project.</td>
</tr>
<tr>
<td>How do you sensitis the project team to knowledge gathering?</td>
<td>Champions for the topic and incentives. Indicator for maturity of the team members and of the champion. Senior personnel would be selected for the task.</td>
</tr>
<tr>
<td>How do you provide the team time for effective recollection?</td>
<td>Ensure that it is an in-process activity. Would be included in the project charter. 6 monthly or annual feedback sessions.</td>
</tr>
<tr>
<td>How do you ensure that corporate knowledge databases are used</td>
<td>Give direction to the project teams to access the company databases regarding the application of project knowledge through the use of the internal search engine.</td>
</tr>
<tr>
<td>effectively?</td>
<td></td>
</tr>
<tr>
<td>How is the learning disruption from disrupted projects minimised?</td>
<td>Industrial psychologist, productivity changes within the project team, preparation for the project disruption to the project team. Step changes in the project could be beneficial. There is a distinct role for the project sponsor in the project disruption process. Sponsor role in the team psychology. Require regional experience in change behaviour.</td>
</tr>
<tr>
<td>Does your client understand the full effect of project disruptions?</td>
<td>Generally, not. The project disruption does not affect the client as much as it will affect the EPCM Company. Must be raised to the highest level in the client organisation to manage the transition correctly. Changes have a cost impact that usually results in conflict if not communicated and understood early enough. The further along the project life cycle the project is, the higher the level of client engagement required in change management. This is seldom understood by the client Project Manager/ Director.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Do you see knowledge management as a driver of innovation?</td>
<td>Blue sky thinking must be tempered with experience so as not to overload the project with too much innovation. Often is at the opposite end of the spectrum.</td>
</tr>
<tr>
<td>How is recorded knowledge utilised to the benefit of the company?</td>
<td>Used to win contracts as a key differentiator.</td>
</tr>
<tr>
<td>Do you see knowledge management as a means for attracting top talent?</td>
<td>As a key attractor for top talent – definitely. Indicates stability in the company. Indicates speed and agility in the company and a definite retention capability.</td>
</tr>
<tr>
<td>What are the corporate benefits of knowledge management?</td>
<td>Benefits in sales and marketing of the company and as a method for capturing project experience and technical capability.</td>
</tr>
<tr>
<td>What policies are there for the deployment of personnel into a project environment?</td>
<td>There are various policies for the deployment of personnel. Simpler deployment of personnel from an HR basis can result in failure in execution. HR follow is up essential. Personnel require secure home base back-up.</td>
</tr>
<tr>
<td>How are the personnel inducted into the project?</td>
<td>HR provides support only. Generally, this is poorly managed in the company. There is often site project induction only.</td>
</tr>
<tr>
<td>How do you ensure the team contributes their best to the project?</td>
<td>There is career path development. This would be the job of the project manager to ensure full involvement in the project. Incentives, individual recognition, autonomy support from the rest of the organisation.</td>
</tr>
<tr>
<td>How does the company manage the effectiveness of the human resource?</td>
<td>Not managed well, no company policy for this activity. HR needs to have more exposure to the company “Engine Room” to have a full appreciation of the individual’s stresses, pleasures and what makes them tick.</td>
</tr>
<tr>
<td>How is the competitive advantage of the human resource secured and maintained?</td>
<td>Personal recognition (publically) and close management interaction to create a sense of belonging and value.</td>
</tr>
<tr>
<td>How is the interaction between the company ‘Human Resources’ and the project execution team directed, encouraged and managed?</td>
<td>HR to understand the activities on the project. Must understand the business of the company. Was taken to the project for the day. Site trip organised for spouses, school children and teachers to create a greater awareness of Engineers and support staff skills. This creates a sense of pride.</td>
</tr>
<tr>
<td>How do you involve the ‘human resource’ function in the project?</td>
<td>Involved HR in the project and involved in the report back session. However not certain that this cascades down well enough. KPI reviews are done by line management and piers and not HR department as a result.</td>
</tr>
<tr>
<td>How can human resources impact on the veracity of project delivery?</td>
<td>Can understand the project complexities and the necessity for selection and induction of the project personnel. Involve the line manager to get a better insight into the particular skills required who in turn assesses the development required to realise the full potential.</td>
</tr>
<tr>
<td>How does your company engender the cooperation between the engineering and human resource groups?</td>
<td>No structured approach. Requires a proactive approach and involvement. All should understand the context of the business of the company. Company provides the structure and framework for the line manager to manage his own HR requirements within a matrix organisation.</td>
</tr>
</tbody>
</table>
### Discussion

**Projects are often disrupted how is the impact of this minimised?**

By providing a secure project pipeline and showing the project personnel that personal change and project stoppages are an aspect of projects and a part of the natural project execution process. The critical mass of a larger company makes the transitions smoother than in smaller companies.

**Do you see a connection between project performance and knowledge transfer?**

Generally, the better the project performs the better the project transfer is conducted. The mature project leaders ensure past knowledge is accessed and used to improve the projects chances of success.

**Do you have a policy for knowledge transfer? Who do you select for this purpose?**

There was no strict policy for this in the company; the new EMS system ensures this is done regularly. The knowledge transfer process is currently conducted by the more experienced personnel in the company.

**What would you understand by the term community of practice?**

This is the way the company does something. BHP would be a good example of this approach to doing business. Understood as a gate keeping process.

**What would you understand by the term knowledge community?**

Specifying the way things are done in the company. Should understand the client and the client knowledge community. Should understand the knowledge available from the professional associations, Governments and contractor communities.

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#### 5.5.3.3 Teams

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
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<tbody>
<tr>
<td><strong>What drivers do you use to model and build your project team?</strong></td>
<td>The requirements of the project and the location of the project execution site. Past experiences, skills, energy levels required from the team, project team personalities, client personalities, governments focus areas and potential contractor’s skills.</td>
</tr>
<tr>
<td><strong>What are your main constraints when building your project team?</strong></td>
<td>Availability of the project resources and the mobility of the project team members. Utilisation figures determine profitability which requires that the company keeps under-utilisation to a minimum. The mobility of personal is dependent on the individual’s life stage and lifestyle. The challenge is getting all of this to match your projects requirements.</td>
</tr>
<tr>
<td><strong>How are engineers’ skills identified and quantified?</strong></td>
<td>Reputation, history and preferences. Do not rely on the CV exclusively for information on the candidate. Use personal knowledge of the candidate. Information is captured on the ‘YOU’ page within the company.</td>
</tr>
<tr>
<td><strong>How are team deficiencies identified and addressed?</strong></td>
<td>Managed between the colleagues. Engineering Manager feedback. Head of Department, Project Manager and Client feedback. Project sponsor activity to collate the feedback should it be raised at higher levels and not have been dealt with adequately.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
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</tr>
<tr>
<td>How do you or would you manage your virtual project team?</td>
<td>Careful selection of the team. Managing the estimates for the work. Using the Head of Department in the matrix structure to allocate the resources. HR to be involved in the project and to schedule personnel into the project activity. Manpower cost management. Managing and match the team output and KPI's. Using systems designed for the purpose. Live international systems. Red Dot – accountable persons to be trusted.</td>
</tr>
<tr>
<td>Are you using geographically dispersed project teams?</td>
<td>Commodity aspect to the Engineering activity in the project. This is happening now – commodity aspect to the procurement of engineering activities, the way of the future. The new approach to completing activities as an EPCM company demands a global approach to ensure competitiveness and to ensuring the “A-Team” is offered to the client.</td>
</tr>
<tr>
<td>Define the term - socialising?</td>
<td>Socialising of project problems/ requirements. Refining of the problems/ challenges and communicating them. Allocation of time, meetings, project maturity, and coffee breaks to set the culture of socialising and good communication etc.</td>
</tr>
<tr>
<td>What do you understand by digital socialising?</td>
<td>Blogs, social network sites, electronic communication to call for a far reaching/ expansive audience.</td>
</tr>
<tr>
<td>How would you encourage and facilitate team building with a geographically dispersed project team?</td>
<td>Daily communication using emails, “telephone calls” and conference calls. Team building is a daily business not a once off event. Fun activities are required to galvanise the team.</td>
</tr>
<tr>
<td>How is cross-firm socialising encouraged?</td>
<td>Attending Association events, sponsored events, communication etc. on a mature level.</td>
</tr>
<tr>
<td>How effective are meetings in knowledge sharing in teams?</td>
<td>Very effective if presented at the correct level and quality as there is a culture of ongoing learning.</td>
</tr>
<tr>
<td>How effective is the telephone in team socialising?</td>
<td>20% if the team does not already know each other on a one on one basis. 50% if they do.</td>
</tr>
<tr>
<td>How effective is email in team socialising?</td>
<td>20% if not overdone. 10% if overdone.</td>
</tr>
<tr>
<td>How effective is the company extranet in team socialising?</td>
<td>50% if the individual takes the time to read it. 0% if he does not.</td>
</tr>
<tr>
<td>How effective are web based project teams?</td>
<td>For small simple projects they can be 100% effective. Larger projects that require interaction and decision making need one on one personal interaction as 80% of communication is unspoken/ unwritten.</td>
</tr>
<tr>
<td>How do you retain your best people in an economic downturn?</td>
<td>Have critical mass of projects, provide client with a pro-active plan to save them money in the long term by bringing work forward in the short term. Be diverse enough to redirect them into other industries that can use their skills. Finally, make a strategic decision to retain key personal where you can show a business case to do so.</td>
</tr>
</tbody>
</table>
### 5.5.3.4 Complexity and uncertainty

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
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<tbody>
<tr>
<td>What do you understand by the term complexity?</td>
<td>Where more than one skill is involved to derive at a desired solution.</td>
</tr>
<tr>
<td>What do you understand by the term uncertainty?</td>
<td>Where one or more outcomes may be possible.</td>
</tr>
<tr>
<td>How do you differentiate between risk and uncertainty?</td>
<td>Risk is “what if” scenario planning of the uncertainty and how they can be treated individually and if they should present themselves simultaneously.</td>
</tr>
<tr>
<td>What are the key drivers of complexity and uncertainty?</td>
<td>More than one solution with more than one risk presents itself. Then a matrix is required to systematically identify and then address the possible permutations.</td>
</tr>
<tr>
<td>What are your sources and consequences of project complexity?</td>
<td>Different opinions, experiences, expectations, behaviours, maturity, understanding, cultures which result in misalignment of expected outcomes.</td>
</tr>
<tr>
<td>How do you manage complexity?</td>
<td>Through a systematic process of getting everyone aligned at the various stages of the project to focus and support one desired outcome.</td>
</tr>
<tr>
<td>What are the benefits of complexity?</td>
<td>They present multiple options and outcomes.</td>
</tr>
<tr>
<td>What do you understand by project dynamics?</td>
<td>The culture in which a project performs and also operates in.</td>
</tr>
<tr>
<td>What effect would significant project changes have on the project team?</td>
<td>The team may choose to support it or sabotage the change.</td>
</tr>
<tr>
<td>What effect does pacing of the project have on project complexity?</td>
<td>Through pacing a project team may be guided through the decision making to reach the point of consensus.</td>
</tr>
<tr>
<td>What do you understand by information biases?</td>
<td>When there is an error in probability judgement, as a result of incorrect assumptions (based on past experience). This results in an incorrect measurement/ result forecast.</td>
</tr>
<tr>
<td>What would you describe as being the origins of biases?</td>
<td>Past experiences.</td>
</tr>
<tr>
<td>How does your project team manage the many stakeholder relationships?</td>
<td>By appointing stakeholder managers to attend to various stakeholders and at various stakeholder levels. These are referred to as sponsors, managers, directors etc.</td>
</tr>
<tr>
<td>How does this skill develop?</td>
<td>It is acquired through association at various levels and is coached.</td>
</tr>
<tr>
<td>What pattern does this relationship follow</td>
<td>It starts as an introduction to determine matching personality types. Once that is established a relationship can be developed on a professional and personal level to establish trust. Once that has been achieved it is maintained for years ahead.</td>
</tr>
<tr>
<td>How does the level of uncertainty vary during project execution?</td>
<td>The beginning starts with a lot of uncertainty during concept and pre-feasibility. As the project progresses the uncertainty is reduced to (10% ideally before execution begins).</td>
</tr>
<tr>
<td>How should the execution team address project complexity?</td>
<td>Identify the options, do trade off studies, get change approval if needed, adjust schedule and cost estimate.</td>
</tr>
<tr>
<td>What would you see as being the role of the client organisation in uncertainty management?</td>
<td>To manage the process according to the project charter and as expediently as possible.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
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</tr>
<tr>
<td>What is the benefit of client knowledge sharing?</td>
<td>The client is more involved and empowered.</td>
</tr>
<tr>
<td>What would you describe as being uncertainty consciousness?</td>
<td>Knowing of the unknowns.</td>
</tr>
<tr>
<td>What would you say is the upside of uncertainty?</td>
<td>It gets the ‘creative juices’ flowing.</td>
</tr>
<tr>
<td>How is uncertainty managed?</td>
<td>Identified, acknowledged, responsible person appointed to address, impact identified, opportunity identified and fast decision making.</td>
</tr>
<tr>
<td>How would you describe the EPCM uncertainty management maturity?</td>
<td>Matured and systematic.</td>
</tr>
<tr>
<td>How can flexible strategies (options) in this realm assist in conditions of uncertainty?</td>
<td>Options create opportunities but needs management to prevent chaos. A change management policy assists in addressing the procedures of management change.</td>
</tr>
<tr>
<td>How can an effective uncertainty management program benefit the project?</td>
<td>It prevents chaos in the project environment.</td>
</tr>
<tr>
<td>How would you measure uncertainty?</td>
<td>Against available options which are measured against time and cost as primary measurement. The cost of secondary affect is then also measured.</td>
</tr>
<tr>
<td>What would you understand by the term WBS granularity?</td>
<td>The detail/ number of elements to which the WBS is broken down.</td>
</tr>
<tr>
<td>How would you manage design activities in period of uncertainty?</td>
<td>Stop them progressing until certainty is achieved.</td>
</tr>
</tbody>
</table>

### 5.5.3.5 Project gaps

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you understand as being a project gap?</td>
<td>The difference between where the project is and a desired future/ end gap.</td>
</tr>
<tr>
<td>What would you consider to be a gap?</td>
<td>The need for more work to be done before you can proceed further.</td>
</tr>
<tr>
<td>What were the instigators of project gaps?</td>
<td>Third party involvements such as Government approval, shareholders, further work to eliminate uncertainty.</td>
</tr>
<tr>
<td>How do you prevent gaps from appearing?</td>
<td>Identify obstacles early enough and allow sufficient time for them to be addressed.</td>
</tr>
<tr>
<td>How does the information flow vary during the execution of the project?</td>
<td>In the beginning the big picture is addressed and understood, and then more detail is required as an output which requires detailed information from suppliers, designers and engineers through detailed communication. Finally, the information is translated into orders and instruction which are followed as specified.</td>
</tr>
</tbody>
</table>

### 5.5.3.6 Project crisis

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would you view as being a project crisis? Example?</td>
<td>When something/ event takes place that will deviate from the desired/ planned outcome.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>What opportunities does a crisis present?</td>
<td>To review the risk register and view what the action plan detailed.</td>
</tr>
<tr>
<td>What reduces the likelihood of a project crisis?</td>
<td>Proper scenario planning, risk reviews, construction schedules etc.</td>
</tr>
<tr>
<td>How can the effect of a project crisis be mitigated?</td>
<td>Scenario planning, emergency preparedness, drills, contingency, back-up planning etc.</td>
</tr>
<tr>
<td>What practices can instituted/instilled?</td>
<td>Project procedures that are well communicated and practiced.</td>
</tr>
<tr>
<td>What is the crisis philosophy?</td>
<td>There must be a pre-determined policy, procedure and training manual/ induction manual that explain what the steps are that need to be followed until the crisis is over and normality is restored.</td>
</tr>
</tbody>
</table>

### 5.5.3.7 Project failure

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What would you say are the determinants of project failure?</td>
<td>When the end state is not achieved or is achievable.</td>
</tr>
<tr>
<td>What are the non-technical failure indicators?</td>
<td>Cost and time over runs.</td>
</tr>
<tr>
<td>What are the contributing causes to project failure?</td>
<td>Deviations, outside influences not controlled by the project team.</td>
</tr>
<tr>
<td>What would you say are the failure contributors?</td>
<td>The management team does not guide the project end state and address deviations to either achieve the end state or alter the end state.</td>
</tr>
<tr>
<td>What role does the project manager play in project failure?</td>
<td>He accepts responsibility for all project failures.</td>
</tr>
<tr>
<td></td>
<td>He steers the project to success.</td>
</tr>
<tr>
<td>What short cuts contribute to project failure?</td>
<td>The incorrect start-up of the project is where most short-cuts occur. The project charter is where the systems, methods, planning takes place.</td>
</tr>
<tr>
<td>What role does program management and planning play in project failure?</td>
<td>A major part. If you 'fail to plan you plan to fail'</td>
</tr>
<tr>
<td>What role does changes of objectives and requirements play in project failure?</td>
<td>Major. The secondary effect of change is usually underestimated.</td>
</tr>
<tr>
<td>What role does project complexity and global distribution play in project failure?</td>
<td>Not much if they are planned correctly. In fact, they should lead to success.</td>
</tr>
<tr>
<td>What remedial actions could prevent project failure?</td>
<td>Regular measurement of progress and steering accordingly.</td>
</tr>
<tr>
<td>What do you understand by tipping point failures in projects?</td>
<td>An event or occurrences that changed the direction and outcome of the project that cannot be reversed or remedied.</td>
</tr>
<tr>
<td>How do tipping point failures manifest themselves?</td>
<td>Due to outside interference/ influence that are out of the project management control. Due to those that were in the PM control are due to lack of control, planning, and management.</td>
</tr>
<tr>
<td>What would you say are the drivers for tipping point failures?</td>
<td>Lack of experience.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
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<tr>
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</tr>
<tr>
<td>What would you say are biases that contribute to project failure?</td>
<td>Personnel arrogance.</td>
</tr>
<tr>
<td>What project culture would mitigate the propensity for project failure?</td>
<td>Commitment, dedication, experience sharing, motivation, and humbleness.</td>
</tr>
<tr>
<td>What effect would the regulatory environment have on the delivery of projects?</td>
<td>They can stall or delay a project but seldom accelerate the delivery.</td>
</tr>
<tr>
<td>How are ‘project failure’ learning points captured into the company learning?</td>
<td>Through 'lessons learnt' registers.</td>
</tr>
<tr>
<td>How do individual stakeholder objectives affect the project outcomes?</td>
<td>Seldom if the project is well structured and there are ongoing checks and balances.</td>
</tr>
<tr>
<td>What effect does poor planning have on project outcomes?</td>
<td>Huge effect. Good quality planning leads to success. You only get what you measure on projects.</td>
</tr>
<tr>
<td>What would you say are the main categories of project planning errors?</td>
<td>Underestimation due to over optimism. No contingencies or insufficient contingencies. Late measurement. Links not being understood and managed.</td>
</tr>
<tr>
<td>Would a greater operational link for the project reduce the propensity for project failure?</td>
<td>Yes, the client will end up getting what he wants.</td>
</tr>
</tbody>
</table>

5.5.3.8 Project success

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What defines the success of your project?</td>
<td>Meeting all the milestones in scope, quality, cost and time.</td>
</tr>
<tr>
<td>How is the project success measured and displayed?</td>
<td>Schedules and cost estimate milestones met and communicated to celebrate successes and improve motivation.</td>
</tr>
<tr>
<td>Has your project suffered from a disrupted program?</td>
<td>Yes, significantly.</td>
</tr>
<tr>
<td>What was the nature of this disruption?</td>
<td>Eskom power delivery to site was late.</td>
</tr>
<tr>
<td>How can success be better assured in project partnerships?</td>
<td>If both parties have the same to lose or gain from failure or success.</td>
</tr>
<tr>
<td>Are the ‘critical success factors’ an assistance to decision making?</td>
<td>Yes, creates a focus point for all parties.</td>
</tr>
<tr>
<td>What factors would you say are critical for project success?</td>
<td>Sound project structure. Suitable personnel. Adequate resources.</td>
</tr>
<tr>
<td>What would you say are key contributors to success in an International environment?</td>
<td>Communication, trust, integrity, common understanding between project team members, suppliers and client.</td>
</tr>
</tbody>
</table>
### 5.5.3.9 Conflict management

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
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</thead>
<tbody>
<tr>
<td>Has there been any conflict during the execution of your project?</td>
<td>Yes, significant.</td>
</tr>
<tr>
<td>What was the nature of this conflict in a project environment?</td>
<td>Dispute on certification and bonus entitlement.</td>
</tr>
<tr>
<td>What are the main causes of conflict in a project environment?</td>
<td>Misalignment and interpretation of the scope of work, schedule, quality and costs. Between the client and the EPCM contractor.</td>
</tr>
<tr>
<td>How do you minimise the sources of conflict in a project environment?</td>
<td>Water tight through contracts, early engagement, communication, transparency and fairness.</td>
</tr>
<tr>
<td>What are the detrimental effects of conflict in a project environment?</td>
<td>Results in loss of trust, poor team morale and loss of dedication.</td>
</tr>
<tr>
<td>What are the positive effects of conflict in a project environment?</td>
<td>Shows commitment, urgency and discipline.</td>
</tr>
<tr>
<td>How would you resolve conflict between two parties?</td>
<td>Address the issue and not the personalities.</td>
</tr>
<tr>
<td>How would you arrive at a resolution?</td>
<td>Achieve a common understanding of the issues and reach a fair compromise.</td>
</tr>
<tr>
<td>What could be source of conflict in a global project in the design phase?</td>
<td>Packaging the scopes and estimation of the resources to achieve the package objectives.</td>
</tr>
<tr>
<td>What could be source of conflict in a global project in the construction phase?</td>
<td>Interaction with other contractors, missing milestones that have a secondary consequential effect.</td>
</tr>
<tr>
<td>How would you manage conflict in a global project?</td>
<td>Communication must be superior and capable of crossing international boundaries and time zones.</td>
</tr>
<tr>
<td>What is the influence and effect of global procurement on project failure?</td>
<td>None if properly managed in the international arena.</td>
</tr>
</tbody>
</table>

### 5.5.3.10 Project management philosophy

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
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</thead>
<tbody>
<tr>
<td>Why do you think project management principles have become widespread in industry?</td>
<td>It has become a common process language which has improved communication and aligned expectations.</td>
</tr>
<tr>
<td>Why do mining projects generally have significant overrun on costs and schedule?</td>
<td>The geology is uncertain. Mining Engineers are often over optimistic, and biased.</td>
</tr>
<tr>
<td>Is the PMBoK® way fully applicable to long term mining projects?</td>
<td>Yes, without reservation.</td>
</tr>
</tbody>
</table>
### 5.5.3.11 Last planner

<table>
<thead>
<tr>
<th>Aspect</th>
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<tbody>
<tr>
<td>What detail of planning is in place at the start of the project?</td>
<td>One level below what is required as it is missing the tendered contractor's schedules and works on previous project benchmarks.</td>
</tr>
<tr>
<td>What time planning horizon do you look at?</td>
<td>For large long duration projects: 10 years, 5 years, 1 year, 1 month, 1 week and then 1 day.</td>
</tr>
<tr>
<td>Do you have a buffer of tasks for the design or construction crews?</td>
<td>Yes, there is always a buffer of activities to keep the engineering and construction teams busy.</td>
</tr>
<tr>
<td>How do you monitor the task completion performance on your project?</td>
<td>The task completion is monitored by the supervisors and the planner records the completion progress.</td>
</tr>
<tr>
<td>How does the ‘Last Planner’ facilitate the project?</td>
<td>Communicates the detailed schedule and measures the achievements. Handles the interactions and resultant complication from overruns.</td>
</tr>
</tbody>
</table>

### 5.5.3.12 Agile project management

<table>
<thead>
<tr>
<th>Aspect</th>
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</thead>
<tbody>
<tr>
<td>What is your definition of a project?</td>
<td>Something that has a defined scope with a defined start and completion date (duration).</td>
</tr>
<tr>
<td>What would you understand by the term ‘agile project management’?</td>
<td>Able to compromise and still achieve the objectives, and an ability to work around.</td>
</tr>
<tr>
<td>What would you see as being the advantages of agile project management?</td>
<td>The execution team would be able to work around problems and challenges and keep the project going. The client would have to accept this process from the outset.</td>
</tr>
<tr>
<td>What would be the requirements for implementing agile project management?</td>
<td>Having a suitable team, or suitable senior team members. The client must accept this process.</td>
</tr>
<tr>
<td>When would the use of agile project management tactics be advantageous?</td>
<td>When there is uncertainty in the project or a changing scope.</td>
</tr>
<tr>
<td>What would be the basic tools of agile project management?</td>
<td>A versatile team and an amenable client. A flexible procedural base from the EPCM.</td>
</tr>
<tr>
<td>Why would improvisation be a prerequisite?</td>
<td>To be able to use pre-established designs and to rework existing and completed packages. This would assure agility.</td>
</tr>
<tr>
<td>What would be the role of improvisation in project management?</td>
<td>Quick thinking and to be able to accommodate changes in a mining project environment. Would minimise the effect of changes on the execution program.</td>
</tr>
<tr>
<td>What would you see as being the challenges of agile project management?</td>
<td>Not being constrained by over proceduralised systems Teams that are not well integrated. Poor formal communication requires informal communication at a high level.</td>
</tr>
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</table>
### 5.5.3.13 Project systems

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
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<tbody>
<tr>
<td>Does the company adopt project management principles throughout the entire company?</td>
<td>No it does not. Support departments are run according to the best practices of the discipline, not necessarily on project management principles.</td>
</tr>
<tr>
<td>What would be the benefits of the EPCM Company embracing a project management methodology in all aspects of the business?</td>
<td>There would certainly be a greater cross company understanding of the nature of the business and the support would be better.</td>
</tr>
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### 5.5.3.14 Project control in uncertain environments

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<tr>
<th>Aspect</th>
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<tbody>
<tr>
<td>How would you define project uncertainty?</td>
<td>Uncertainty of scope, delivery and program.</td>
</tr>
<tr>
<td>Ambiguity is seen to be a cause of uncertainty, what do you see as the drivers of uncertainty?</td>
<td>The client is not sure what they want and when they want it. Often the client does not have sufficient information to make an informed decision, or want to keep their options open.</td>
</tr>
<tr>
<td>How would uncertainty affect the decision making process within the project?</td>
<td>The client would be unable to make a decision. This would spill down to the EPCM who would not have sufficient guidance to complete packages in line with the program.</td>
</tr>
<tr>
<td>Is the traditional matrix environment appropriate in an uncertain and turbulent environment?</td>
<td>The project team has to work as an integral unit. This would not be dependent on the matrix structure of the organisation.</td>
</tr>
<tr>
<td>How does senior management respond to increasing levels of uncertainty?</td>
<td>Senior management not linked directly to the project prefers certainty as this generates assured revenue.</td>
</tr>
<tr>
<td>How does senior management view and react to deviations from the established project plan?</td>
<td>This is generally seen as being not good. Deviations from the established project plan require explanation and may require the project to be retendered.</td>
</tr>
<tr>
<td>How does the project team react to increasing uncertainty in the project?</td>
<td>Uncertainty creates concerns in the project team. The project team often does not have the full picture of the project and the project environment and thus cannot feel comfortable in an uncertain project environment.</td>
</tr>
<tr>
<td>How does your management style change in an uncertain environment?</td>
<td>A greater amount of time has to be put into team communication and team meetings. Where decisions have to be taken then these have to be made more decisive.</td>
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### 5.5.3.15 Managing multiple projects

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<tr>
<th>Aspect</th>
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<tbody>
<tr>
<td>How would you describe a multiple project environment?</td>
<td>Managing more than one project; either for the same client, in the same project environment, or managing multiple projects for different client. The projects could either be in the same field or in different fields.</td>
</tr>
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<td>Aspect</td>
<td>Discussion</td>
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</tr>
<tr>
<td>What challenges does running multiple projects present?</td>
<td>Greater numbers of clients and stakeholders. Establishing a schedule for interaction on these projects and keeping all of the stakeholders satisfied. Maintain momentum on all of the projects.</td>
</tr>
<tr>
<td>What are the problems related to managing multiple projects?</td>
<td>As above. Prioritising the effort to be expended on each of the projects particularly if the projects are for different client. Applying uniform standards across all project particularly where clients have differing requirements to be satisfied.</td>
</tr>
<tr>
<td>How does the company structure support managing multiple projects?</td>
<td>The company has no specific procedures for the management of multiple projects. Resourcing multiple projects can be challenging.</td>
</tr>
<tr>
<td>What are the key aspects for companies managing multiple projects?</td>
<td>Communication, communication, communication. Having uniform standards across projects to make the managing of multiple projects easier and the communication simpler.</td>
</tr>
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### 5.5.3.16 Relational contracting

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<th>Aspect</th>
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<tbody>
<tr>
<td>What do you understand by the term relational contracting in a project environment?</td>
<td>Establishing a good working relationship with your key suppliers particularly where there is a need for ongoing support in the execution for the project.</td>
</tr>
<tr>
<td>What is the value of relational contracting in a project environment?</td>
<td>There is a need for OEM support, particularly where there is a risk of delays that could impact on the project delivery. Where there is an ongoing need for ongoing technical support. Where the OEM is required to carry spares for the equipment installed and commissioned.</td>
</tr>
<tr>
<td>How would you interpret relational employment in a project environment?</td>
<td>Where external suppliers are required for specific technical support and where these resources cannot feasibly be carried solely by the EPCM as the continuity of utilisation cannot be assured.</td>
</tr>
<tr>
<td>How would you interpret relational outsourcing in a project environment?</td>
<td>As above but as a process of outsourcing of specific activities that could be done by the EPCM. These suppliers would be nurtured by the EPCM and would develop a trusting cooperative relationship.</td>
</tr>
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### 5.5.3.17 Fast-tracking

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<tbody>
<tr>
<td>What is your interpretation of the term fast tracking?</td>
<td>Program compression to meet or improve on project delivery or package delivery. Program aspects would be compressed or items would be run concurrently.</td>
</tr>
<tr>
<td>Why are projects fast-tracked? What are the benefits of fast tracking?</td>
<td>To improve the program schedule, or to catch up on the program where delays have been incurred in execution for whatever reason. Fast tracking can give the client an earlier return on investment for the client and save the project.</td>
</tr>
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<td>Aspect</td>
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</tr>
<tr>
<td>What risks does fast tracking induce in the project?</td>
<td>Fast tracking can bring additional cost to the client whom would have to be balanced against the value of the earlier returns or traded off on the NPV of the project. There can be a risk in the design of the components and late changes not being accommodated.</td>
</tr>
<tr>
<td>How would you attain early revenues?</td>
<td>The completed mine would be available either partially or completely for the generation of revenues. The completed plant can be used for the completion of the remaining scope.</td>
</tr>
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5.5.3.18 Large multidiscipline mining (LMM) projects

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<tr>
<th>Aspect</th>
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<tr>
<td>How would you define an LMM project?</td>
<td>High cost, requiring external funding from shareholders or bond issues. Long duration, requiring a careful examination of the project revenues far in the future. Commodity trending. The project environment can change dramatically in the project execution period.</td>
</tr>
<tr>
<td>How do you see the future of the LMM project?</td>
<td>There will be a continuing need for large scale mining projects. More and more companies will be examining existing assets for future development and an earlier return on investment.</td>
</tr>
<tr>
<td>What are the pressures resulting from LMM projects?</td>
<td>The need to gain an earlier than planned returns on the investment and to obtain early returns from the plant completed.</td>
</tr>
<tr>
<td>What are the challenges of LMM projects in the virtual project house?</td>
<td>EPCM companies will be relying more and more on satellite offices to provide work in areas that are not fully occupied with local work. This requires established systems and teams that can function well in this environment. Practice makes perfect.</td>
</tr>
<tr>
<td>What are the favourable trends in LMM projects?</td>
<td>Junior clients that look for the experienced EPCM to provide the resources that they do not hold in house.</td>
</tr>
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5.5.3.19 Project safeguards

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<tbody>
<tr>
<td>What do you understand as being a project safeguard?</td>
<td>This would be the use of the best resources available to assure project success.</td>
</tr>
<tr>
<td>Why would a project safeguard be required?</td>
<td>The client would be looking for an assurance of project success. The substantial investment of the client’s capital in an LMM project means that the client is placing much of its future in one project and one EPCM.</td>
</tr>
<tr>
<td>What would be an example of a project safeguard?</td>
<td>The selection of the best EPCM Company with a proven track record. Retentions and performance bonds.</td>
</tr>
<tr>
<td>What would be an example of a mining project safeguard?</td>
<td>The selection of the best EPCM Company with a proven track record. Retentions and performance bonds.</td>
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### 5.5.3.20 Estimating

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<tbody>
<tr>
<td>What would you say are the challenges presented by estimating on a 'Mega Project'?</td>
<td>The complexity of estimating for the project in an environment where there could be many companies working on similar or identical projects. The number of packages being tendered in the same project.</td>
</tr>
<tr>
<td>What would you say makes for successful estimating?</td>
<td>Having the correct people available for the task being performed. Clear scopes and supporting documentation. A clear definition for the project. What you put in is what you get out.</td>
</tr>
<tr>
<td>What effect can the surfeit of projects have on the estimating process?</td>
<td>Estimates are based on tenders that come from vendors. Estimates generally have a small chance of becoming a contract in the near term so vendors become tired of tendering for work they are unlikely to get in the near term or at all.</td>
</tr>
<tr>
<td>What responses can be expected from the vendors?</td>
<td>Initially good but become lacklustre in the longer term. Tenders can become a cut and paste of previous work therefore can lose accuracy in the longer term.</td>
</tr>
<tr>
<td>Where are the sources of bias and error in estimating?</td>
<td>Reduced accuracy. Weighting the tender or under-pricing in the hope of improving success in the future when the tenders come out for a project in execution.</td>
</tr>
<tr>
<td>What is the effect of cost overruns on the project execution?</td>
<td>This can place great strain on the project as cost overruns could place pressure on the funding available for the remainder of the project. The client representatives will be reluctant to go back to the project sponsor to secure additional funding for the remaining scope of the project.</td>
</tr>
<tr>
<td>Why would you say there is a trend to underestimate during the feasibility study?</td>
<td>This would be to secure the funding for the projects where there are many project out there vying for funding. There would be a general feeling that the funding has to be secured, then in execution the variations can be explained away.</td>
</tr>
<tr>
<td>Why would underestimation persist?</td>
<td>There is a general feeling, particularly with the junior miners that all are underestimating the cost of the project. Similarly, the returns are overestimated and the risks suppressed to make the project the most attractive. Under estimation would there-for be here to stay and the financiers would there for be required to provide an experience based correction factor, contingency.</td>
</tr>
<tr>
<td>What do you understand of the term information asymmetry?</td>
<td>Where there is a difference between what is known and what is divulged. It is though that this would be to give better assurance that the project will be funded. This can either be deliberate or subconscious.</td>
</tr>
<tr>
<td>Is cost underestimation prevalent in both small and large projects?</td>
<td>I would say yes. The under estimation on the larger project would have a greater impact on the financiers of the larger project though.</td>
</tr>
<tr>
<td>How can ‘cognisant’ cost overruns be mitigated?</td>
<td>This can on be achieved in the tendering phase by conducting thorough peer reviews of the project at various stages. There could be a process of cognisant weighting of the project during the tendering process.</td>
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<tr>
<td>Would you say that project returns are similarly biased?</td>
<td>Generally, yes, the Mining Engineers apply a similar bias to the potential returns of the project particularly when it is being 'sold' to the senior management of the mining company. The ore body decision can be based on a cut cost reserve evaluation.</td>
</tr>
<tr>
<td>Would you say that project risks are misrepresented?</td>
<td>Yes, the risks can be easily misrepresented in what is a subjective process. The risk process must be extensive and inclusive to ensure it achieves a fair representation of the true risks that the project can contain.</td>
</tr>
</tbody>
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### 5.5.3.21 Forethought

<table>
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<tr>
<th>Aspect</th>
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<tbody>
<tr>
<td>Do you have open team discussions during the CBE phase of the project?</td>
<td>Yes. All parties are required to contribute in open and inclusive discussions. The meetings have to chaired competently to ensure all can talk and be heard.</td>
</tr>
<tr>
<td>Do you identify people who are 'overinvested' in the project?</td>
<td>We try to identify these persons in the course of this process to ensure the bias they can introduce is sterilised.</td>
</tr>
<tr>
<td>How would you identify potential project failings at the earliest opportunity?</td>
<td>This would be achieved in the processes of reaching an accurate CBE. Risk assessments and unbiased peer reviews. Open team discussions at the various gates the project must pass through during the development process.</td>
</tr>
</tbody>
</table>

### 5.5.3.22 Project risk

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
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</thead>
<tbody>
<tr>
<td>How do you define risk?</td>
<td>The uncertainty of achieving the desired outcome. The probability of any negative occurrence. The negative outcome and the probability of this occurring.</td>
</tr>
<tr>
<td>What would be the basic principle of risk management?</td>
<td>Identify the risk. The impact of this risk. The probability of this occurring. The strategy to mitigate this risk. Measuring the effectiveness of this mitigation.</td>
</tr>
<tr>
<td>What do you see as being the principle risks on your project?</td>
<td>Client sourced significant changes in scope, significant changes in the mining process and the transport strategies. The underperformance of the main sinking contractor, losing skills during the execution of the project and not having a follow on project to absorb the resources coming off the project. This resulted in the loss of skills before the completion of the scope.</td>
</tr>
<tr>
<td>What is the best time to address project risks?</td>
<td>These should be addressed as soon as possible in the project execution so the effect of the risk is minimised. As soon as a new risk is identified it must be quantified and action taken to mitigate.</td>
</tr>
<tr>
<td>What would you see as being the two principle sources of risk?</td>
<td>Client originating. People and environment. EPCM originating. People and environment.</td>
</tr>
<tr>
<td>Aspect</td>
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<tr>
<td>In the team gathering process what would say are the challenges?</td>
<td>Identifying the resources required for the project execution. Having the resources required at the time they are required, resource inertia. Obtaining the client acceptance of the resources required for the project, being understaffed for the execution of the project.</td>
</tr>
<tr>
<td>What would be the principle human risks?</td>
<td>Human behaviour and developing compatible teams.</td>
</tr>
<tr>
<td>How should knowledge gaps be addressed?</td>
<td>Training, training, training. Mentoring, mentoring, mentoring. Having an experienced core to the project team.</td>
</tr>
<tr>
<td>What would you describe as being operational risks?</td>
<td>The ability of the personnel from the EPCM, Client and main contractor to be able to execute the tasks required to the required quality.</td>
</tr>
<tr>
<td>Do you evaluate business risks as well as operational risks?</td>
<td>This is done within the EPCM company using various techniques. The risks to the EPCM business are evaluated and the risks presented in the project are evaluated. In addition to this are client risks assessments which are carried out to review the business of the client. Operational project risks are also carried out particularly in the sinking environment.</td>
</tr>
<tr>
<td>In the risk analysis process are internal and external risks contemplated?</td>
<td>All are evaluated in the holistic risk management process. &lt;li&gt;Client&lt;/li&gt; &lt;li&gt;EPCM&lt;/li&gt; &lt;li&gt;Contractor&lt;/li&gt;</td>
</tr>
<tr>
<td>What are the basic steps you follow in the risk analysis process?</td>
<td>Identify the risks Ranking of the risks using the Delphi techniques Evaluation of the risk impact.</td>
</tr>
<tr>
<td>Can you be certain that all risks are identified in the initial risk management processes?</td>
<td>This cannot be assured; only the risks apparent to the risk assessment team can be identified. The process can assure that if maintained the risks can be identified as they become apparent in the execution process.</td>
</tr>
<tr>
<td>What would you say are your project’s five principle risks?</td>
<td>Client changes of scope – significant. Eskom power availability. Fundamental design oversight. Main Contractor performance. Commodity price slump.</td>
</tr>
<tr>
<td>What are the sources of these risks?</td>
<td>&lt;li&gt;Client&lt;/li&gt; &lt;li&gt;Contractor&lt;/li&gt; &lt;li&gt;External environment&lt;/li&gt;</td>
</tr>
<tr>
<td>Who is the best party to manage or take ownership of these risks?</td>
<td>Client takes ownership. All parties take responsibility to mitigate.</td>
</tr>
<tr>
<td>What role does communication play in the risks management process?</td>
<td>Communication is key to managing the risk environment. Everyone must understand the risks and take part in the identification and mitigation of the risks. New risks must be communicated.</td>
</tr>
<tr>
<td>In project execution what would be the principle risks facing the large scale project?</td>
<td>&lt;li&gt;Resources&lt;/li&gt; &lt;li&gt;Capital availability&lt;/li&gt; &lt;li&gt;Contractor performance&lt;/li&gt; &lt;li&gt;Scope changes&lt;/li&gt;</td>
</tr>
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<tr>
<td>Are the conventional risk management processes appropriate for large scale projects?</td>
<td>Generally, they are ok for the LMM project but it is essential that the risk management process is continuous for the duration of the project. This repeat process must be as thorough as the original process.</td>
</tr>
<tr>
<td>For large scale projects would it be more appropriate to be proactive as opposed to being reactive?</td>
<td>The fundamental of the risk management process is to be predictive/proactive, to identify the risks up front. The second aspect of risk management in the risk management process is to be reactive. To be able to respond to risks as they manifest themselves in execution.</td>
</tr>
<tr>
<td>What new risks are introduced by managing a portfolio of projects?</td>
<td>Managing many projects introduces a prioritising conflict for the project manager. If this involves multiple clients, then this would introduce a conflict in off-site communications and arranging sufficient time to meet with all of the clients in a suitable time period.</td>
</tr>
<tr>
<td>Is the current risk management process suited to managing the portfolio of projects?</td>
<td>It should be compatible for managing multiple projects. There would be a necessity to hold a risk management session for the project manager to highlight the risks associated with the multiple project environment.</td>
</tr>
<tr>
<td>What would you describe as being intuitive risk management?</td>
<td>Risk management based on the experience of the project team. This will enable the team to fast-track the risk management process and to bypass some of the time consuming process. The channelling of the process must be avoided though.</td>
</tr>
<tr>
<td>What new risks can subcontractors introduce?</td>
<td>The subcontractor can come into the project without the knowledge of the project history. An additional level of communication is added to the project. The new contractor will have to be brought up to speed quickly on the project communication strategies and responsibilities.</td>
</tr>
<tr>
<td>Are all risks manageable?</td>
<td>All risks can be managed to a certain point; they can therefore be managed. Some risks may not warrant any action.</td>
</tr>
<tr>
<td>Are all risks managed?</td>
<td>Some risks may not be managed by the project team and be documented and recorded. Subsequent risk management sessions will review these risks for relevance and possible changes in status.</td>
</tr>
<tr>
<td>Are all risks declared at the inception of the project?</td>
<td>No, some risks may not be identified and would only be picked up later by a different team in the Risk Assessment.</td>
</tr>
<tr>
<td>How would your categorise risks?</td>
<td>Risks can be categorised by different methods: • WBS, • Area, • Perceived occurrence, • Cost of risk event, • Cost to mitigate.</td>
</tr>
<tr>
<td>Are some risks ignored?</td>
<td>All risks identified will be monitored by the project team. All risks will be evaluated. Some risk may not require any mitigation effort.</td>
</tr>
<tr>
<td>Why could some risks be ignored?</td>
<td>Insignificant risks could be side-lined. Risks with low risk of occurrence or low cost of impact would be side-lined. Risk that have a high cost of impact and cannot be mitigated may become show stoppers.</td>
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</tr>
<tr>
<td>Are you aware of all the risks present in your project?</td>
<td>Certainly not. Though all the risks that have been identified I am aware of. Should any new risks be tabled I will take responsibility for and introduce a mitigation strategy.</td>
</tr>
<tr>
<td>Is all risk evaluation and risk management satisfactory?</td>
<td>Generally yes though should the risk strategy prove to be ineffective then the mitigation strategy will be revised to ensure the risk response is adequate and effective.</td>
</tr>
<tr>
<td>• Does your client apply an early design commitment strategy?</td>
<td>We try to do this to ensure the client is committed to a project completion strategy. This is applied to ensure the design and drawing office have clear guide lines and there is efficient utilisation of the design resources. Generally it is successful but there must be full client buy in to this process. Late changes are controlled by changes of scope from the client and a detailed review process by a multidiscipline group.</td>
</tr>
<tr>
<td>• Why is this applied?</td>
<td></td>
</tr>
<tr>
<td>• Is it successful?</td>
<td></td>
</tr>
<tr>
<td>• What about late changes to the project definition?</td>
<td></td>
</tr>
<tr>
<td>Do you practice design postponement to as late as possible to minimise risk?</td>
<td>This would be an ideal situation to be in. often the client requests an early commitment. Delaying the design input may give greater clarification of the design commitment. Delaying the design process could result in challenges should the project completion date be brought forward.</td>
</tr>
<tr>
<td>What factors affect the client’s decision to expedite the design process?</td>
<td>The perceived cost efficiency of the early design and drafting completion. This could have a penalty of rework should the client decide to change some of the fundamental design criteria for the project.</td>
</tr>
<tr>
<td>To what extent is concurrent engineering practiced?</td>
<td>Where it is practicable to run some items concurrently. There is a risk that the EPCM cash flow might exceed the client’s budget for the activity.</td>
</tr>
<tr>
<td>What risks are induced by the EPCM Company and Client processes?</td>
<td>There is a greater opportunity for the client and the EPCM to be in conflict. Some of the processes could be contradictory. In the execution process.</td>
</tr>
<tr>
<td>What are the project specific challenges relating to concurrent engineering?</td>
<td>Some of the design aspects might be reliant on the completion of other executables. There is a risk that rework on one aspect could result in rework on all of the aspects. For example, a change in pump sizing could result in rework in piping, civils and structural steelwork.</td>
</tr>
<tr>
<td>What would you say are the risks introduced by globalisation?</td>
<td>There should be none. Communication, time-zones, cultures, standards, building standards, traditions and so on would have to be taken into consideration before the globalisation initiative is undertaken.</td>
</tr>
<tr>
<td>Have you considered using a risk breakdown structure?</td>
<td>This has not been considered to-date. The risks identified in the current processes are clearly understood. Should a larger project be undertaken where there are multiple work areas being undertaken simultaneously then perhaps the RBS process could be beneficial.</td>
</tr>
<tr>
<td>Are the risks on your project affecting the business clearly understood by all on the project</td>
<td>Generally not. The risks are openly declared in the project documentation but more time could be used to ensure there is clear awareness of all of the project risks.</td>
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### 5.5.3.23 Project sponsorship

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<tr>
<td>What would you say is the role of the project sponsor?</td>
<td>The project sponsor is there to identify and select the project manager and in some cases the lead engineer for the project. These people are the core persons for the project. The project sponsor is to act as a high level bridge between the project team and the client project management. The project sponsor will ensure the project execution remains on track at the highest level and to maintain communication with the client to the benefit of the project.</td>
</tr>
<tr>
<td>What would you say are the beneficial attributes of a project sponsor?</td>
<td>High level political player in the company. Ability to manage the company interface. Good networks for finding key resources. Excellent communication skills.</td>
</tr>
<tr>
<td>How does this role differ between the Client sponsor and the EPCM Company sponsor?</td>
<td>The Client sponsor operates in the client environment and primarily has the client’s needs as a primary concern. The EPCM Sponsor has the EPCM needs at heart and the profitability of the EPCM is a primary concern.</td>
</tr>
<tr>
<td>What would you say are the key behaviours of the project sponsor?</td>
<td>Keep the project execution in context. Understand the big picture of the project in execution. Support the project team without managing the project. Follow the project progress closely without becoming too involved in the project. Manage the client interface keeping the developing opportunities in mind.</td>
</tr>
<tr>
<td>What would you say would be successful outcomes for the project sponsor?</td>
<td>The project completed on time, on budget, and a satisfied client. New opportunities developing from a satisfied client.</td>
</tr>
<tr>
<td>What would you say would be detrimental sponsor behaviours?</td>
<td>Neglecting the project due to too many commitments. Becoming too involved in the project without this being necessary. Not being aware of the development of the project and the up-coming project challenges. Not supporting the project team.</td>
</tr>
<tr>
<td>How should the project sponsor behave during the execution of the project?</td>
<td>The project team has to be allowed to manage the project. The project manager must be supported and there should be regular interaction with the project team. Execution risk should be identified early on so that they can be addressed in good time before they become execution crises.</td>
</tr>
<tr>
<td>What would you say are the principle project sponsor failings?</td>
<td>Lack of high level interaction with client senior management. Falling behind in the project execution and not being in the picture when called in for assistance. Becoming over involved in the project day to day activities disempowering the project team. Becoming too client orientated.</td>
</tr>
<tr>
<td>How would you overcome inadequate project sponsorship?</td>
<td>The project sponsor would be bypassed. Interacting directly with the senior management of the client organisation and the EPCM organisation.</td>
</tr>
</tbody>
</table>
What would you say are the challenges facing the project sponsor in the EPCM Company environment?

There is a high level of complexity in the project environment and managing more than one client interface can be a significant challenge. The project sponsor would be required to sponsor many projects creating a conflict of interest between the various projects being sponsored. The project sponsor may have a conflict of interest between the EPCM host and the activities on the project. The project sponsor would be involved in business development activities. Which cause a lack of involvement in projects in execution.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the fundamental drivers of project communication?</td>
<td>To inform and involve personnel in the project. Communication can be internal to the company, for all personnel involved in the project, to the client group. Communication can become group wide to inform the entire EPCM company of project performance.</td>
</tr>
<tr>
<td>How did you establish your communication strategy?</td>
<td>Identify the personnel to be involved in the project communication. Identified the items to be communicated. Identified the form of the communication, and the frequency of this communication. Identify the key meetings, the frequency of these meeting and the persons to attend.</td>
</tr>
<tr>
<td>What are the negative effects of poor communication?</td>
<td>Misinformation. Thus poor decisions. Irritation. Incorrect scheduling.</td>
</tr>
<tr>
<td>Is all communication on your project formal?</td>
<td>There is extensive informal communication in the project environment. The informal communication has to be managed particularly where it goes outside the project team and to the client. Informal communication has a significant value to the project team and can build bridges.</td>
</tr>
<tr>
<td>What is the value of informal communication?</td>
<td>Building networks of value between disciplines and internal to disciplines. The heuristics developed can improve the value of the deliverable to the client.</td>
</tr>
<tr>
<td>Who is responsible for the communication on the project?</td>
<td>Ultimately the Project Manager. Formal communication is through the company systems managed by the document controller.</td>
</tr>
<tr>
<td>What is the root cause of the proliferation of asymmetric information?</td>
<td>Asymmetric information is used to form and manage opinions by giving only the information that supports the senders preferred opinion. Asymmetric information is often the easier opinion to accept and generally supports the project execution.</td>
</tr>
<tr>
<td>What is your interpretation of asymmetric information?</td>
<td>Is used to support an opinion and contrary information is suppressed. Asymmetric information is also the withholding of information that could be detrimental to the sustaining of an opinion.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
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</tr>
<tr>
<td>What are the possible effects of asymmetric information?</td>
<td>Decisions are made on faulty information. This puts pressure on the project execution team to achieve unrealistic targets and aspirations. The project struggles to achieve objectives.</td>
</tr>
<tr>
<td>How can asymmetric information be compensated for?</td>
<td>Getting all parties around the table. Clear and unbiased peer reviews of the project. Second opinions on critical decisions.</td>
</tr>
<tr>
<td>What are the advantages of a competent communication system?</td>
<td>All parties are aware of the project deliverables all of the time. A clear and self-explanatory project dashboard. All persons have the correct information to make decisions, good decisions can be made.</td>
</tr>
<tr>
<td>What are the challenges confronting effective communication?</td>
<td>There can be changes in the stakeholder group that go unnoticed. The information to be circulated has to be reviewed for accuracy prior to being distributed. People have to be informed in the correct sequence. The informal network sometimes is faster that the formal network and could result in contradictory reports being received.</td>
</tr>
<tr>
<td>How can communication be used to manage the client perceptions?</td>
<td>Communication has to be clear and non-contradictory. The information has to be in the correct format. This information enables the client to make good and timely decisions. Clear communication creates a good impression of the EPCM performance.</td>
</tr>
</tbody>
</table>

5.5.3.25 Project close-out

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the execution of the project are life-cycle costs considered?</td>
<td>These are considered in the design process, to ensure the project deliverables suit the client needs for running and maintenance costs. Energy usage is a fundamental concern for clients in the mining industry in South Africa.</td>
</tr>
<tr>
<td>What post project completion changes have been executed on your project?</td>
<td>Some changes to the conveyor systems and to the mud handling philosophy. The client took over much of the installations before the final commissioning had been done.</td>
</tr>
<tr>
<td>What are the root causes of post project changes?</td>
<td>Not involving the client in the conceptual layouts. Fundamental changes in the client camp, this introduces changes in thinking that have to be accommodated. This can be accommodated in change requests and decision notes but are often attributed to poor EPCM activity.</td>
</tr>
<tr>
<td>What post project changes are taking place?</td>
<td>Changes in the staffing requirements for the project. Changes to the scope of the project after the project has been completed. Changes to the surface ore handling arrangements. Changes to the information to be collected from the underground operations. Additional capacity required from the shaft requiring a change to the winder capabilities.</td>
</tr>
<tr>
<td>Aspect</td>
<td>Discussion</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>What are the effects of changes in a project?</td>
<td>The entire project would have to be reviewed to ensure the impact on the project can be accommodated by the other components of the project that have been completed. The client has to agree to the changes to the project. The costs and time required to execute have to be accepted.</td>
</tr>
<tr>
<td>What are the main causes of post project changes?</td>
<td>Changing demands on the project in terms of tonnage output. Unclear design criteria. Unclear and poorly defined deliverables. Changing project environment; labour costs, energy costs, water constraints, and host mine performance.</td>
</tr>
<tr>
<td>What can be done to reduce or mitigate post project completion changes?</td>
<td>Involving the client as much as possible in the design and concept process as executed by the EPCM. Obtain a client brief that is as clear and as complete as possible. Client sign off on all completed concepts. Involving the client at an operational level in the design process so the completed project is as far as possible operationally ready. Ensure packages are signed off by all parties and handed over to the client as they are completed.</td>
</tr>
</tbody>
</table>

5.6 Post interview activities

At the completion of the interviews the hand written notes and the verbal comments were transcribed by the author into the text. The typed responses were edited by the author for grammar and spelling.

5.7 Conclusion

Chapter five presented the empirical study methodology, the interview questionnaire and a response to the interview questionnaire.

The responses to the interviews are analysed in chapter six, the analysis was for specific trends in the responses, lack of understanding of the concepts and insightful responses.

Chapter 6: Interview analysis

6.1 Introduction

In chapter six the responses from the interviews were collated and analysed. All of the interview responses were transcribed by the author so that they could be collated into a single document and codified by the author. This was then analysed by the author for predominant responses, trends in the responses that could quantified and for novel responses that could be analysed further.

This was done to establish a trend in the understanding of the topic, establish trends in the responses, to identify key issues raised by the interviewees and to ensure there was no personal
bias introduced. This analysis was then referred back to the key issues for topic raised in the literature review.

The interview question is contained in the shaded block and all the responses are analysed in the text below the shaded block.

6.2 Project leadership

Describe your leadership style.

Most of the respondents have adopted a motivational management style giving the staff a free rein to perform their tasks. There is an approach of giving opportunities for individuals to develop in the project environment.

There is generally an atmosphere of trust where the leader gives guidance and takes strategic decisions where required.

Is the same management style used for all situations and for all team-members?

There was overall agreement that the management style would have to differ depending on whether they were operating in a site or design office environment and the seniority of the personnel. Some respondents discussed the situational environment which would require a differing approach.

Has your project required a change in leadership style during execution?

There was a marked difference in the responses to this question. Generally, there has been no change in the management style adopted for the EPCM staff except where this has been in response to a change in management style from the client, this included micro-managing the EPCM staff.

In execution some of the respondents noted that a different management style towards the contract staff was required.

Some of the respondents noted that they had not changed their management style.

Does your leadership style positively influence team performance?

All of the respondents agreed that their management style had a positive effect on the team performance. One commented that an underperforming team had transformed into a well performing team under the influence of their management style.
How would you say your leadership style has affected the work performance of your subordinates?

Most commented on improved work performance and individuals enjoying taking ownership and enjoying the greater responsibility that a more liberal management style encourages. There was a greater up-take of knowledge within the team. One respondent commented that some site personnel were more challenging; this was attributed to the different working environment.

What skills should a project manager possess?

Most of the respondents agreed that the project manager should have a relevant technical skill and a broad base of experience in the project deliverable. In addition to the above it was indicated that the project manager should have a sound financial understanding.

What selection criteria are used for Project Managers?

Most of the respondents agreed that the project manager should have previous project experience, project management skills, communication skills, team building and leadership skills. In addition, the project manager should the technical skills to understand the technical challenges of the project. One respondent indicated that there should be a good personality fit with the client and the client organisation.

How do you deal with the internal (Company) administration?

All agreed that the internal administration is necessary; some indicated that it could be excessive; one indicated that it would be avoided as far as possible. Some of the responses indicated that they would delegate specific tasks to responsible team members. One of the responses discussed that there was a fine line between the ideal administration and the point where it become intrusive and affects the project performance.

On what criteria should a Project Manager be evaluated?

Most of the respondents would evaluate the performance of the project manager on the standard criteria of measurable of time, cost and quality.
In the LMM project environment safety performance would also be a key measurable. Other criteria for a few respondents considered the human resource; staff turnover and team satisfaction.

6.3 Human resources and knowledge management

**Does the company have knowledge management processes?**

Most agreed that either these did not exist in the company, were very rudimentary and poorly applied or were too cumbersome to be effective in providing knowledge from previous project experiences.

Some of the systems discussed were too complex to be understood easily.

**Do policies exist for Tacit and Explicit knowledge management?**

Some of the respondents say that these policies exist; some of the respondents say that the policies do not exist.

Respondents suggest that the explicit knowledge gathering exists partially in the engineering structures of the company but this is not complete and thorough. Tacit knowledge gathering is not being practiced and this information is in the personnel of the company.

Respondent reflect on the lessons learnt processes for gathering knowledge but that this process is not freely available between projects.

**Do policies for capturing knowledge exist?**

It was generally agreed that there is a lessons learnt process that captures some of the knowledge accrued from project execution.

There was general agreement that this was not be practised well in the organisation and obviously should be improved.

There was agreement that this was not freely transmutable across projects.

**Does tacit knowledge get captured into computer tools?**

This was generally seen to be a failing with the respondents.

One of the respondents stated that this knowledge is protected by the individuals as it was seen to be a competitive advantage for the individual. People were seen to be too busy to write down knowledge for capture. This was seen as a time consuming exercise after the project was completed.
How do you encourage the divulging of tacit knowledge?

Most of the respondents suggest that this should be done through structured or informal meeting such as the ‘Lunch and Learn’ meeting. Some of the respondents said that the KPI process and the mentoring sessions should be used for the divulging of tacit knowledge.

Most of the respondents said that this process was weak.

The lessons learnt register was also referred to by one respondent as a process for the divulging of tacit knowledge.

How do you manage knowledge gathering in environments of overload, ambiguity and politics?

Most of the respondents agreed that the conditions of overload, ambiguity and politics should not get in the way of knowledge gathering.

Most would resort to the process of meetings and formal documentation to capture and record the knowledge gained. The client should approve documents to eliminate or assist with mitigating ambiguity.

Engineers should spend time in the field and at vendors to embed the learning gained in the office.

What is the strength of the engineering culture within your project/ company?

The responses on this topic generally favoured the idea that the engineering culture is strong within the company. The response from outside the company reflected on the ability to access engineering consultancies outside the company and contract in the necessary expertise.

Responses also reflected on the lack of homogeneity within the company, but generally good within the project.

One of the respondents commented on the interest in the engineering aspects of the projects but lamented the administrative tasks that often take precedent.

How is the ‘Engineering Culture’ modified to the benefit of the project executables?

One of the respondents commented on the development of a company that retains talent.

The general opinion was that the organisational culture was the overriding culture of the company and that this would take precedent over the engineering culture.

One of the respondents said that the engineering culture is suppressed and the main focus was on the internal administration processes with little focus on good engineering.
When transposed into the client structure with pressure on delivering packages the pressure of the environment was seen to take precedent.

**Is knowledge gathering always successful?**

There was a generally negative response to this question with most respondents agreeing that the knowledge gathering process was poor and the information gathered often inaccessible.

One of the respondents stated that it was not possible at the time of gathering to know what would be useful and what would not.

Knowledge gathering would have to become part of the company culture.

**Is knowledge management a primary concern?**

Generally, the respondents indicated that it was not a primary concern of the company but clearly should be.

In the Client embedded EPCM environment the focus was not on knowledge management but on completing the deliverables.

One of the respondents was positive on this aspect; the project was working on the feasibility study and the early works simultaneously.

**How do you sensitise the project team to knowledge gathering?**

One of the respondents identified the need to identify a champion for the task, preferably a senior project member. Knowledge gathering should be a primary project objective and collective knowledge is of great value.

One identified the need to make this a clear instruction and to use a structured database for this purpose.

**How do you provide the team time for effective recollection?**

Most agreed that this would have to be in a structured meeting of some description involving the entire project team or an engineering group.

This would be more or less frequently; some were every six months and some more frequently even weekly catch up meetings for the entire project group.

One of the respondents suggested that there was no need for a meeting unless there was a specific task requiring a meeting.
One respondent suggested that the schedule should provide for recollection and knowledge sharing.

**How do you ensure that corporate knowledge databases are used effectively?**
The one response from a client project manager was the sole custodian on the engineering database.
Most respondents suggested that the database has to be easily accessible and should be front of mind as a source of information.
One of the respondents stated that if the database is useful and easily accessible it will be used.

**How is the learning disruption from disrupted projects minimised?**
One respondent described the role of the sponsor in disrupted projects. Most of the respondents described the business as usual approach in so far as the teams must be focused on maintaining the project momentum and keeping the core team members together.
Disrupted projects and team cuts according to one must be seen as part of the project activity and the team guided through the process.

**Does your client understand the full effect of project disruptions?**
The responses were both yes and no for this aspect. Some clients understand and some do not. Some clients are only focused on the project deliverables and are not concerned about the EPCM tribulations and see it as the responsibility of the professional organisation to manage. Some clients do not understand the impact on the project that occurs when the project is disrupted.
Some projects have the foresight to factor in risk assessments during the baseline risk assessment.

**Do you see knowledge management as a driver of innovation?**
Most disagreed with this statement seeing knowledge management as being rooted in the tried and tested and innovation being at the opposite end of this spectrum.
According to one of the respondent’s knowledge creates habits and thus repeated actions.
One respondent saw the opportunity in freeing the innovation by using acquired knowledge to solve the more menial and repetitive tasks.

**How is recorded knowledge utilised to the benefit of the company?**
Though some thought that this aspect is weak in the company most thought that the company would benefit from arriving at satisfactory solutions quicker giving the company an operational benefit.

One respondent thought that the knowledge database would provide the company with a marketable advantage over opposition companies.

**Do you see knowledge management as a means for attracting top talent?**

Most agreed that the top talent would be attracted to a company that has a reputation for delivering cost effective solutions, and this would be indicative of a stable and effective company.

People would want to benefit from the employment experience and this would come from a solid project pipe line supported by effective solutions.

One noted that this is seldom a question asked by interviewees.

**What are the corporate benefits of knowledge management?**

Most commented on the benefits to the company’s reputation in being able to reach cost effective solutions quickly in all phases of the project, knowledge also reduces the project execution risk as there would be a reduced risk of error. This would have the benefit of opening up opportunities for new work.

This would also allow individuals to operate to their full potential.

**What policies are there for the deployment of personnel into a project environment?**

Generally, there are policies for the deployment of personnel into the company and into the project, though one respondent suggested there was no company policy for this activity. One respondent indicated that HR should be involved in the process of deployment but should not have the sole responsibility for this activity.

One respondent indicated that this is dependent on the activities on the project and the demands being placed on the EPCM at that time.

Some indicated that this was the domain of the Head of Department and they would be responsible for the recruiting processes.

**How are the personnel inducted into the project?**

Most often, according to the respondents this is not done well by the company, the company induction lacks all-encompassing content.
Project induction varied from a well-structured induction covering the critical aspects of the project, to a client driven induction to being the personnel into the operating systems of the client, to a very perfunctory project induction on a remote site where the individual is expected to fit in.

**How do you ensure the team contributes their best to the project?**

Most included the process of specific encouragement and a monitoring process for the performance of the individual. It was important for the individual to be self-driven and feel that their input was a valued element of the total project.

There should be incentives according to one, this would be coupled to the company’s performance measuring scheme.

**How does the company manage the effectiveness of the human resource?**

Some lamented that fact that this is not done effectively by the company. The diversity of the responses would also reinforce the perception that this is not done well in the company.

One indicated that HR should become more involved or informed about the company’s core business in order to become more effective.

**How is the competitive advantage of the human resource secured and maintained?**

One indicated that it is necessary to keep the staff challenged and select those that like to be challenged. Another indicated that it is necessary to give personal recognition.

Others indicated that the EPCM does this poorly and the KPI system is ineffective in the way it is applied.

The responses to this question were diverse and would seem to reflect the perceptions of the project manager.

**How is the interaction between the company ‘Human Resources’ and the project execution team directed, encouraged and managed?**

One respondent indicated that this something that needs to be encouraged particularly on a project level, support personnel need to become aware of the site activities and constraints.

Most agreed that there was little interaction between ‘Human Resources’ and the project execution team, one remarked that this would be at the discretion of the Project Manager’.

The EPCM project team embedded in the client premises however had two weekly meetings between the project senior personnel and the senior HR person. These meetings discuss HR aspects.
How do you involve the ‘human resource’ function in the project?

Most of the responses suggested that there was little interaction between project and the human resources function; this was to be left to the Head of Department. Any interaction would be on an as required basis and through direct interaction.

The response from the client side project indicated that human resources would be involved in the project from the outset and would be responsible for the project manning from the start.

One respondent indicated that human resources would be involved in the gamete of activities such as the disciplinary process and retrenchment discussions.

How can human resources impact on the veracity of project delivery?

Most indicated that there is more that can be done by the human resource function in the company.

One respondent indicated that the human resources effort needed to be simplified, and that the human resource function should reflect some of the drivers for the project teams.

How does your company engender the cooperation between the engineering and human resource groups?

Most agreed that this is not done well in the company and interaction is forced. There seems to be no structured approach to this activity in the company but a distinct need to ensure all in the company understand and support the business of the company.

In the smaller client group company there is a direct involvement of the HR manager at the inception of the project.

There are some meetings where HR issues are discussed and there is the link between the Head of Department and the project manager.

Most agreed that there was rudimentary involvement of HR in the project activities and that this involvement should be improved.

Projects are often disrupted how is the impact of this minimised?

Often this is by treating this as a common project occurrence and ensuring that there is a project pipeline that can be called upon to absorb unallocated resources.

Some remarked that this is not done well in the company.

The project needs to be correctly closed out and reports generated.
HR needs to be involved in the downsizing process and have contingency plans in place to absorb the resources.

**Do you see a connection between project performance and knowledge transfer?**

All agreed with this statement and the intent. Some stated that the project would have to be a long duration project, but the responses considered the two aspects of knowledge transfer:

- Transfer into the project to improve the project performance through the utilisation of knowledge of what works.
- The retention of knowledge through the better performance of the project, under the premise that if the project is performing badly the less likely people will want to talk about it and if the project is performing well the more likely people will want to talk about it.

**Do you have a policy for knowledge transfer? Who do you select for this purpose?**

Most agreed that there is no company policy for this activity but the activity exists within the company, some of the individual projects have their own policies controlling knowledge transfer and retention.

One response identifies this as being a mentoring type of activity and this would naturally fall into the responsibility of the senior engineers in the project team. There could be more than one mentor in the project team.

**What would you understand by the term ‘community of practice’?**

Most saw this as being fundamentally the way the company or community does something of tackles challenges.

One of the respondents was this being embedded by the use of regular meetings, discussion groups and communications.

One of the respondents saw this outside of the shared company practices and saw this as being a small company with the greater team interacting to develop a clear understanding of the challenge and a feasible solution.

**What would you understand by the term ‘knowledge community’?**

Most saw this as being a main office activity where groups develop knowledge and ensure that this is distributed amongst the team members.

Some referred to a specialised group within the company to ensure the information is captured and made to be fundamentally available and easily searchable.
6.4 Teams

What drivers do you use to model and build your project team?

Generally, all agreed that the scope and location of the project would be a common starting point to be able to select the personnel for the project. Most agreed that the requirements of the project in terms of relevant experience and skills, one stated that there should be some skilled leaders in the team to bring the team together.

Some of the respondents saw the starting point being the identification of those whom they have worked with before.

It was noted by one respondent that the resources with the company are often constrained so you would often have to make do with what is available.

What are your main constraints when building your project team?

Most commented on the availability of the resources and key resources being committed to other projects. The mobility of resources would also be a constraint according to one and the need to drive the utilisation of resources within the company.

It was noted that the company can recruit into the project but this is dependent on availability in the outside market. The client would of course, as noted, have to pay for the experienced resources and the completion of the team numbers.

How are engineers’ skills identified and quantified?

Most described the use of the CV and interviews. It was noted that this should not be relied on to be definitive. Reliance could be shared as described on personal experience, recommendations and working experience.

The client interview indicated that experience from previous working contact would be a strong recommendation.

How are team deficiencies identified and addressed?

According to most of the responses the team deficiencies are normally identified by feedback from the project manager or from the client. From most responses these should be dealt with at the project level initially.

One response stated that should this not be effective then it would be the project sponsors responsibility to collate the feedback and address the deficiencies.
According to one the project key performance indicators would indicate a project requiring attention.

The response from the client group indicated that the behaviour of the project manager should be such so as to address deficiencies before they affect the project performance.

**How do you or would you manage your virtual project team?**

One response highlighted the need for careful team selection, cost control, company systems, live international purpose developed systems and accountability.

In a similar vein was the identification of regional heads managing the teams, accessible databases and common performance metrics. Internet communication was highlighted as a tool to bring together the project teams.

One respondent indicated that there was no substitute for carefully planned and executed visits.

**Are you using geographically dispersed project teams?**

There was an even split between yes responses and no responses.

One of the yes responses indicated that this required a much stricter control of the teams as the contact time was reduced and that the deliverables had to be clearly defined.

One response discussed the necessity to develop skills in managing geographically dispersed teams and to embrace the commodity approach to engineering activities.

**Define the term ‘socialising’?**

Most of the respondent saw this as the process of bring the team together to refine the problems and challenges of the project, developing the team communication strategies and the establishment of common team goals.

Some reflected on the sharing of project information through various means. One reflected on the orientation of the team members in the direction of an established team.

**What do you understand by ‘digital socialising’?**

All described in some way the use of electronic media and the virtual environment to achieve the socialising of the team. Techniques included the use of email, Skype, Lync, telephones, portals and so on to bring the virtual team together.
How would you encourage and facilitate team building with a geographically dispersed project team?

The client group response accepted that there would be additional cost but it was essential to enforce that the dispersed teams would attend all meetings, this was considered necessary when building cohesive teams.

One respondent indicated that it would be necessary to establish team leaders in the regional centres to champion team building activities. Other respondents indicated that the teams would have to develop separate cultures; another indicated that team building would be difficult.

How is cross-firm socialising encouraged?

Some indicated that this is not being done as a company strategy and one indicated that this was not being done because of the current poor industry trends.

One saw this as an avenue to meet counterparts from other companies, this would be through industry association meeting and sponsored events. One indicated that the company wide social media could be used for this purpose and the gathering areas in the building.

The response from the client group indicated that the smaller size of the company necessitated cross-firm socialising.

How effective are meetings in knowledge sharing in teams?

Most agreed that meetings can be effective in knowledge sharing and that the process is essential. The caveat that most concurred on was that the meetings have to be well managed, effectively chaired and recorded.

One respondent indicated that the meeting should not just be for the purpose of knowledge sharing but that this should be an agenda item for the meeting.

How effective is the telephone in team socialising?

One response indicated that the telephone can be effective if the team links have already been established.

The responses were in general neither affirming nor non-committal. The telephone does, according to the respondents, remain an important form of communication, particularly where no visual input is required. One respondent suggested that the telephone should be used more, and one indicated that an email should be sent after the conversation to confirm the conversation.
How effective is eMail in team socialising?

The responses were mixed regarding the use of email for socialising. The responses indicated that email is an important form of communication but would not be a direct substitute to other techniques such as the telephone. One of the respondents indicated that email can be more precise and in general email tend to be devoid of non-relevant information. One respondent indicated that for socialising the email is ineffective and often the correspondence is shared, socialising required a flow of conversation that not viable in the email sphere.

How effective is the company extranet in team socialising?

The responses indicated personal preferences regarding the extranet. Most of the responses were not in favour of the company extranet saying that it is not used by the staff and as such is not valuable in socialising. Most personnel according to one respondent prefer face to face discussions for socialising.

How effective are web based project teams?

Most of the respondents indicated that they had little exposure to this form of team building and for managing project teams. One of the respondents stated that this could be effective for simple projects, but for larger projects direct communication would be required. Some of the respondents indicated that this is novel but would be the way of the future for the EPCM companies but would require a change in the way business is done and the way project are executed.

How do you retain your best people in an economic downturn?

The key part of this question was ‘economic downturn’. According to one respondent the key is to prioritise the retention and development of talented personnel. One respondent stated that it is essential to have a critical mass of diverse projects and to encourage clients to capture the benefits of bringing the work forward. One stated that training should be focused into the quite period and training specifically designed to diversify the skills of your key staff members.
Some of the respondents stated that the best people should be allocated to the most challenging project; this would have the benefit of retaining these skills and giving the client the best performance on their projects with the benefits to the EPCM that this would return.

### 6.5 Complexity and uncertainty

#### What do you understand by the term ‘complexity’?

Most of the respondents saw complexity as being the technical difficulty of the project and the necessity to use a range of technical skills to address this technical difficulty. This would be linked to the difficulty in understanding the technical complexity of the project.

A few of the respondents also saw the complexity in the number of interactions required in the project execution and the necessity to manage a multitude of projects.

One reflected on the aspect of information overload, projects are often not ‘Rocket Science’.

#### What do you understand by the term ‘uncertainty’?

Some of the respondents had no definite answer to this question.

The remaining respondents reflected on the inadequate or incomplete definition of the project and the inability, based on this to make decisions affecting the project outcomes, or where there could be a multiple of possible outcomes.

One of the respondents stated that variations in the scope, increases in the scope and changes in the program would be a source of uncertainty.

#### How do you differentiate between risk and uncertainty?

About half of the respondents understood that risk was the probability of outcomes of known factors, and that uncertainty was the unknown factors.

Uncertainty was the uncertainty of outcomes and risk would be the challenges in reaching known outcomes.

Generally, the respondents could differentiate between risk and uncertainty.

#### What are the key drivers of complexity and uncertainty?

Most of the respondents reflected on the needs of the client and the concurrent expectations of the client. The complexity would be driven by the changes (scope and duration) instituted by the client during the execution of the project.
In addition to the above two of the respondents reflected on the lack of clarity from the client and poor leadership.

**What are your sources and consequences of project complexity?**

Respondents reflected on the technology challenges, the finance constraints placed on the project, the compression or delay on the project program. Some of the respondents discussed the client or client team introduced complexity in the project execution.

The response from the client based interviewee reflected on the complexity of the ore body to be mined.

One reflected on the outcome of this complexity is that people working on the project end up not knowing what to do.

**How do you manage complexity?**

All of the respondents wanted to tackle the complexity in a structured and well communicated manner.

The complexity would be dismantled and communicated to the team; the project planning would be reinforced to address the complexity. The key word from one of the respondents was the 'alignment' of the team.

One of the respondents stated that there was a necessity to identify the key personnel for the project and to have one person championing the teams understanding and then aligning the project staff.

**What are the benefits of complexity?**

Most agreed that complexity can be of benefit to the personnel in generating a more challenging project environment. The personnel would become less complacent; given the opportunities for dynamic communication and brainstorming/ scenario planning, and innovative thinking.

According to some respondents increasing the complexity would improve the efficiency of the team.

**What do you understand by project dynamics?**

Most of the respondents reflected on the changing nature of the project. Projects are accomplished iteratively.

Most of the respondents discussed the day to day adjustments to the project program and schedule required to accomplish the final deliverable of the project. Typically, the day to day
running of the project, negotiating a direction between the various stakeholders and the team members driven by the complexity of the project, options and complex systems.

**What effect would significant project changes have on the project team?**

Most of the respondents reflected on the demoralising effect on the project team. Significant project changes can slow down the project progress, reduce the productivity of the project team and obviously delay the project completion.

One of the respondents reflected on the inevitability of project changes, and another on the opportunity for errors in execution to creep in. Project team members can become over-extended and there could be a necessity to bring in additional team members to manage any additional workload.

One of the respondents reflected on the need to communicate the nature and necessity for the changes to the team to normalise the changes.

**What effect does pacing of the project have on project complexity?**

Most of the respondents agreed that pacing would increase the complexity of the project both from a design and engineering point of view and from the construction activity aspect.

Complexity would be introduced from the necessity to work through project information quickly with the possibility of not being able to consider the information fully, some of the information required for decision making may not be available, and from a construction schedule point of view with multiple activities occurring concurrently.

One of the respondents looked at project delays reducing the complexity of the project but giving the client an opportunity for incorporation of new ideas.

**What do you understand by ‘information biases’?**

Most of the respondents understood this to be the selection of or preference for certain information. The bias can, according to the respondents, come from faulty measurement, incorrect assumptions, poor quality information, withholding information or group preference for a particular course of action.

The respondent from the Client embedded EPCM team had not come across this term in the working environment.

**What would you describe as being the origins of biases?**
Most of the respondent reflected on the human aspect of information biases. According to the respondents this could be the end product of: past experiences or conditioning, conscious presentation of selected information, the interpretation of this information, the preferential capturing of information, and the distortion of data.

Again the respondent from the Client embedded EPCM team had no experience of information biases.

**How does your project team manage the many stakeholder relationships?**

Most of the respondents agreed that this was critical and need to be managed; this would warrant the allocation of specific leaders within the project team and their allocation to specific stakeholders.

Most agreed that guidelines/management plans are required and that the information should be specific to the stakeholders. One of the respondents remarked on the fragile nature of the stakeholder relationship and the necessity to reduce the points of contact.

The Client embedded EPCM team reflected on the stakeholder management plans and the complexity of having four tiers governance, communication and reporting. Not to mention the external stakeholders.

**How does this skill develop?**

Most reflected on the need for continuing exposure to the client and correction and modification of the interaction form and method, building relationships with the stakeholders.

Coaching was tabled by one of the respondents as being a method for expediting communication skill development.

**What pattern does this relationship follow**

The sentiment towards the project from within the client organisation was mooted by one of the respondents as being a driver for the stakeholder relationship.

In general, though the stakeholder relationship building was developed from one of mistrust and uncertainty towards a trusting and professional relationship.

For a long term project these professional relationships would have to be established and developed over many years. The stakeholder relationship would have to be reinforced to be able to survive many troubles in the project execution.
How does the level of uncertainty vary during project execution?

Some of the respondents commented on the reducing level of uncertainty during the execution of the project as the project scope becomes more clearly defined and the items on the project scope are completed.

The client group response was contrary to this, being that the uncertainty during the design and construction would be low as the trade-off studies would have determined the way forward for the project. However, during the commissioning of the project the level of complexity would increase as the performance results would be measured against the design.

During execution, according to some of the respondents, complexity would increase due to the project changes being introduced. The project changes could be scope, program, team expertise or leadership driven.

How should the execution team address project complexity?

Most respondents agreed that the complexity should be addressed in a structured manner. Painstaking planning, and gain the team’s detailed understanding of the plan.

Identify the options, clarification, trade off studies to identify the best option, client approval, revise the schedule and cost estimate.

One of the respondents stated that it is necessary to stick to the terms of the contract and to stick to the project scope.

What would you see as being the role of the client organisation in uncertainty management?

Most of the respondents agreed that the client has a fundamental role in the management of uncertainty. There was general agreement that the client should clarify and communicate requirements early in the execution process as unclear direction leads to uncertainty.

One respondent would expect the client to manage the project process in accordance with the project charter and to be expedient. Regular meetings with the client are essential to ensure information is shared and points of uncertainty are clarified or resolved.

What is the benefit of client knowledge sharing?

One respondent stated that the client becomes more involved and becomes directly empowered.

Most of the respondents agreed that the client knowledge sharing is of great benefit to the project and ensures that the client and the EPCM are ‘on the same page’. The client becomes involved in the package delivery.
One respondent commented that this creates a clear understanding of the client’s needs, elicits better decisions and can prevent costly and unnecessary rework.

The Client embedded EPCM can benefit from lessons learnt from other operations in the client’s organisation.

**What would you describe as being uncertainty consciousness?**

Some of the respondents saw this as being the knowing of the unknowns and the identification of the gaps in the understanding of the project.

Some referred to the conscious awareness of the uncertainties in the project and being able to address them.

One of the respondents took the broader view of uncertainty consciousness, the causes and effects of uncertainty and then the necessity to reduce uncertainty.

**What would you say is the upside of uncertainty?**

One of the respondents could not see the upside to uncertainty, seeing this as a demoralising situation for the project team.

Some of the respondents saw this as a process to stimulate the creativity in the project team. Giving the project team the opportunity to think around the problem and discuss solutions.

Some of the respondents also saw the business opportunity for the EPCM Company and the opportunity for the client to receive a better project with greater returns from the capital investment.

**How is uncertainty managed?**

Most of the respondents would address the uncertainty by identifying the uncertainty, acknowledging the uncertainty then identifying a responsible person to address this.

The uncertainty would be addressed through the change management process and would be priced as a change of scope. The uncertainty would be communicated to the project team as a process for normalising the changes. Significant changes would be subject to the risk management process.

The Client embedded EPCM have extensive processes for risk management and uncertainty was seen as being addressed through the risk management process.

**How would you describe the ECPM uncertainty management maturity?**
Most of the responses from within the EPCM Company stated that the uncertainty management processes were fairly mature. With the nature of mining project in general being uncertain a well-structured approach to uncertainty would be beneficial.

From the client group response there was less confidence in the ability of the EPCM Company to manage uncertainty.

According to one the traditional tools for the management of uncertainty in the EPCM environment would be the application of risk, quality and process planning would be applied.

From the Client embedded EPCM point of view the abilities of the EPCM to manage uncertainty is not as mature as the experienced client’s approach to uncertainty management. There was an opinion in this environment that the EPCM was good at engineering and construction management but was not in a position to put in perceptive risk and uncertainty management.

**How can flexible strategies (options) in the realm assist in conditions of uncertainty?**

From most of the respondent the flexible strategies can create options which can be tabled for the development of solutions. One of the respondents stated that this would have to be well managed to prevent the project from delving into chaos. The EPCM would be developing options or the framework for options.

One noted that in the Post PFS stage of the project implementation of options would have the effect of reducing the team performance.

According to the Client embedded EPCM the flexible strategy would make for a more flexible and more able to respond to the client’s benefit.

**How can an effective uncertainty management program benefit the project?**

The one respondent reflected on the prevention of chaos in the project environment.

Most of the respondents discussed the benefits of preparation for uncertainty and being able to respond in good time to the event. The preparation for uncertainty and having contingencies in place give the team the assurance that this event was prepared for and can be dealt with effectively.

Effective uncertainty management can reduce the team downtime.

**How would you measure uncertainty?**

Two of the respondents had no concept of a measure for uncertainty.

Some of the respondents saw the measurement in terms of project execution variations and the value of scope changes.
One of the respondents saw the measurement of uncertainty as being the collective team’s impression of the extent of uncertainty.

**What would you understand by the term ‘WBS granularity’?**

The respondents understood the term WBS granularity.

Typically, the responses understood that excessive breakdown of the WBS would create more packages but would not necessarily and to the level of control on the project.

As the WBS granularity is reduced the elements of the WBS become more complex and more difficult to manage. The further broken down the WBS becomes the greater the understanding of the project would become.

The less the WBS is broken down the easier the elements would be to manage collectively.

**How would you manage design activities in period of uncertainty?**

Most of the responses agreed that the design work should only continue on the elements that are fully understood and defined.

The packages where there is uncertainty should be delayed until clarity has been obtained.

High level concepts can be continued with and presented for approval; the detail design would be continued once approval has been obtained.

From the Client embedded EPCM the focus would be on not allowing the team progress to slow down in the periods of uncertainty but to rather continue as planned until an approved change comes along.

One response was to continue with the agreed scope until changes are authorised.

**6.6 Project gaps**

**What do you understand as being a ‘project gap’?**

The concept of project gaps was not clearly understood by the respondents.

Some considered this to be the difference between the project is and the desired end state, two considered this to be the difference between what the EPCM is expecting to deliver and what the client is expecting, one considered this to between what is known and what should be known, one considered this to be the site team not managing client expectations, one considered this to be a lack of information, and one considered this to be a planning omission.

One of the respondents considered the project gap to be the gap between the EPCM delivery and the client expectations in terms of deliverable, costing, program and delivery.
What would you consider to be a gap?

The responses follow on from the previous question. Again the responses were diverse.

From the client group the gap was considered to be, for example the gap between the actual grades and the bore-hole grades. This would lead to the understanding that gaps are more apparent between the EPCM Company and the client.

From the EPCM Group the gap definition was more academic centred on client expectations typically; failing to meet client expectations, lack of site team involvement, program delays, lack of information, lack of funds, and gaps in design, concept, delivery and performance.

What were the instigators of project gaps?

Again there was a clear difference in the client group interpretation of project gaps and the understanding in the EPCM group.

From the Client embedded EPCM the understanding was of the planned and unplanned omissions from budget cuts or a lack of understanding of what was required in the budgeting phase of the project.

From the EPCM responses there was a reference to the third party involvement from the State, shareholders and additional work required to address uncertainty.

The other EPCM responses included a lack of common goals, lack of coherent understanding between the client and the EPCM, poor project definition, poor communication, financial constraints and a lack of available data from all sources.

How do you prevent gaps from appearing?

The responses received were geared to addressing the above gaps in information and understanding.

From the EPCM group these were typically; ensuring the information and data was available at the start, communication, all party meetings, involvement, understanding, planning to give timely identification of the risks, absorbing the project complexity, and peer reviews.

From the client group there was a need for adequate funding to know what can be achieved prior to establishing the actions required to get there.

How does the information flow vary during the execution of the project?

Some of the responses reflected on the surfeit of information in the early phases of the project, slowing during the execution and then picking up towards and during the commissioning of the project.
One of the responses reflected in the stakeholder involvement and the complexity of the activities being executed.

According to one of the respondents there was a transition of the information being provided and analysed from the generic to specific. This would according to one be relevant to the stages of package execution and the interest groups being involved from the conceptual modelling to the financial closure and commissioning.

From the Client embedded EPCM there was no concept of any variation in the information flow once the communication rules had been established.

6.7 Project crisis

What would you view as being a project crisis? Give an example.

Again there was a difference between the client group response and the EPCM group responses. Most of the EPCM responses centred on the deviation from the desired outcomes of the project, either in terms of what the client was expecting from what the EPCM was expecting from the project. The impact could be either from externalities to the project and are outside the control of the project team, or internal issues in the control of the project team.

The issues mooted included industrial action and falling commodity prices, or loss of key resources, significant changes in scope or falling behind on the project schedule.

What opportunities does a crisis present?

Most of the respondents saw opportunities in a project crisis. Respondents saw opportunities to think out of the box and find novel solutions, to review the risk register, to refocus the team, and to identify those team members that can work well in a crisis situation and add value to the team.

One of the respondents covered the opportunities for the team and gave the team an opportunity to think laterally.

What reduces the likelihood of a project crisis?

The respondents looked at going back at good project management principles as a means for reducing the likelihood of a project crisis.

The internal project management control:

- Scenario planning, risk reviews, schedules, communication, peer reviews, clear scope definition, cost control, change management and a crisis management plan.

The external environment understanding:
A good understanding of the project environment as a foundation for anticipating the warning signals that would precede a project crisis developing from project externalities.

How can the effect of a project crisis be mitigated?

Most of the respondent understood the necessity of having prepared plans for dealing with a project crisis. One mentioned a ‘Business Continuity Plan’ for use during a strike.

Other mitigation techniques mentioned included scenario planning, emergency preparedness, drills, contingency plans and funding.

The project crisis should be identified as soon as possible and the situation normalised so that the project team can deal with the situation. Some respondents indicated that communication in time of crisis must be honest and punctual so that all can be part of the recovery plan.

What practices can be instituted/instilled?

Most of the respondents reflected on the necessity for crisis control procedures to be practised and well communicated.

The procedures would include, according to the respondents, risk management practices.

The respondents also stated that the warning signals must be detected early; there should be frequent discussions with the client, project status reviews and the maintenance of calm.

What is the ‘crisis philosophy’?

One of the respondents stated that there should be a predetermined policy, procedure and training given for crisis management and the restoration of project normality. This is one point of view.

On the counter point crisis management should be treated as a normal part of the business of the company and that the company is well prepared to address the situation. One respondent reflected on the assessment of the situation, communication and the introduction of an action plan.

It was also noted that as part of the crisis management senior management may become involved in the management of the crisis.

6.8 Project failure

What would you say are the determinants of project failure?

There were differing responses to this question centring on the aspects of time, cost quality and poor planning. In addition, one of the respondents reflected in poor planning, poor control and poor execution.
In a more holistic response one of the respondents reflected the when the end state is not achieved or is not achievable.

From the client group the response reflected on the imbalance between the budget and the required outcome, poor transfer of information, lack of or not understanding responsibilities of personnel in the project and an over-commitment of resources.

**What are the non-technical failure indicators?**

There was a diverse range of responses to this question, some were drivers and some were indicators.

The indicators cited included; over budget, outside the schedule, high project team turnover, team demoralised, NCR’s from various sources, non-payment for work done, poor earned value indicators.

Lack of closure in the EPCM processes was cited as an example as a failure indicator by one respondent; design, drafting, procurement for example. Failures can obviously come from the EPCM processes and from the Client processes.

**What are the contributing causes to project failure?**

Again in this area there was diversity in the responses received.

From the client group response there were seen to be contributors; non participation from key stakeholders and internal staff training being insufficient or not relevant to the project requirements.

From the EPCM group embedded in the Client organisation the key issues were failing to identify and heed the warning signs and failing to react to the warning signs.

From the traditional EPCM group the key contributing causes were; poor communication, imprecise or incomplete design criteria, asymmetric information, unrealistic expectations, continually changing project objectives, poorly applied project controls, team morale not managed, poor leadership.

**What would you say are the failure contributors?**

Most of the respondents discussed management guidance and leadership, in a similar vein there was a discussion of the management controls, management influences and management involvement these included; resources, executive support, and planning.

One of the respondents viewed the changes in the management structures as a failure contributor and a change in scope or program at a critical stage in the project execution.
In line with the poor team morale would be the team’s unwillingness to submit to the project controls.

From the Client embedded EPCM team the following issues were identified as being failure contributors; poor team makeup, poor team quality, poor project manager, excessive client involvement and a contractor that performs poorly (resulting in rework).

**What role does the project manager play in project failure?**

Most of the respondents held the project manager ultimately responsible for the success or failure of the project, the project manager holds a key role in the success of the project.

Most of the respondents reflected on the technical role requirement for the project manager, most reflected on the administrative role of the project manager and most reflected on the leadership role of the project manager.

As one respondent stated; the project manager is responsible for ensuring the controls are instilled, actioned and followed.

According to the client group respondent the project manager should be communicating with the stakeholder groups and the project team. In addition, the project manager should find the time to manage the processes as well as the project controls.

**What short cuts contribute to project failure?**

Most of the respondents discussed the short cuts taken in the start of the project, typically in; project controls, scope definition, planning, budgeting, and defining specifications, contract establishment, and detailed design.

In execution the respondents discussed the failings in the quality management processes, program and scope changes, and planning.

From the experience of the Client embedded EPCM team the key issues were the aspects of incomplete design (a common feature of mining projects), the loss or removal of key team members or disciplines and the selection of poor key contractors resulting in delays and excessive rework.

**What role does program management and planning play in project failure?**

All of the respondents saw the significance of program management as a key to the success of the projects, therefore as one of the respondents put it ‘if you fail to plan you plan to fail’.
The respondent from the client group stated that the planning must keep pace with the changes to the project execution; the planning must be in sufficient detail to allow scrutiny to identify the risk areas in the project.

Most of the respondents agreed that the program is the fundamental tool used by everyone in the establishment of the time frames for the project.

The response from the Client embedded EPCM echoed the above with the comments the project program must be given sufficient attention so that problems can be picked up early enough.

What role does changes of objectives and requirements play in project failure?

The response from the Client embedded EPCM gave the following insight, ‘often project fail because the requirements are changed and the project team attempts to absorb the change and still deliver. When they can’t they are blamed for the project failing’.

Most of the respondents echoed this sentiment and stated that the changes have to be communicated, incorporated in the planning for the project and reflected on the business case for the project.

The change management process has to be followed, and the project owner has to accept the changes.

What role does project complexity and global distribution play in project failure?

Some of the responses saw this as an opportunity for the EPCM to perform well providing the controls are applied correctly and the planning for this is good.

One of the respondents stated that the project complexity and the global footprint have to be factored into the planning.

Some of the respondents reflected on the challenges presented by the time differences and culture to effective communication between the project team members.

According to the Client embedded ECPM the main risk presented by global distribution would be the coordination of the project team.

What remedial actions could prevent project failure?

Most of the responses reflected on the need for a clear scope, capital management, planning, communication, project controls, peer reviews, and quality assurance. Some reflected on the need to keep the stakeholders correctly aligned.

One stated that there was a need for regular re-measurement and then adjusting the project accordingly.
If the project is already off track then, according to one of the respondents there is a necessity to re-baseline the project and perhaps replace some of the staff.

What do you understand by ‘tipping point failures’ in projects?

Two of the responses understood the classical meaning of the term tipping point failure; where the construction team becomes overly occupied with the rework activities and the quality assurance failures on the project. This become too much for the project team to manage along with the project activities of construction.

Most of the respondents saw this as the point where the project failure becomes inevitable.

One of the respondents reflected on the backlog of activities becoming so great and demanding so much activity that the project team cannot meet the project objectives.

How do tipping point failures manifest themselves?

There was a diverse set of responses to this question.

One of the responses indicated that the project execution team become swamped by the quantity of rework and quality issues to the point where they cannot make progress on the tasks that they would have coped with easily.

Another response indicated that the project schedule shows a task backlog that if completed would result in the project not meeting the schedule objectives. One of the response indicated that the tipping point failures cannot be detected and when they do occur are irrecoverable.

What would you say are the drivers for tipping point failures?

One of the respondents saw the two sides of tipping point failures; the uncontrolled scope changes adding to the work load of the staff and the other point being the additional workload generated by the rework and the quality issues.

One of the respondents saw the selection of poor contractors as being the originator of the rework and quality issues to be managed by the construction team. In addition to this was the poor control over the contractor and the failure to identify the ensuing risks.

One of the respondents added the increasing project complexity being a driver towards the tipping point.

One of the respondents added the lack of controls regarding scope, time and cost masking the tipping point failure.
What would you say are biases that contribute to project failure?

As would be expected there was a diverse set of responses to this question. The response from the Client embedded EPCM was that this question was not understood.

The biases listed by the respondents included:

- Personnel arrogance
- Failure to conduct a holistic review of the project
- Project decision being led by people overinvested in the project
- Group think situations going undetected
- Failing to review all data, reviewing only recent data
- Not reviewing the situation objectively
- Over allocating resources
- Selective opinions
- Unsupported confidence
- Adopting a blame culture
- Stubbornness
- Not using lessons learnt and past experiences
- Not maintaining a focus on the project management principles

What project culture would mitigate the propensity for project failure?

Most of the responses received for this question revolved around the project team and bringing the project team together through various means:

- A culture of open non punitive, all embracing communication.
- A culture of problem solving, not assigning blame.
- A culture of collective sharing of ideas and experiences.

One of the respondents stated emphatically that project management is a team sport.

From the Client embedded EPCM come the comment that you need a dynamic and agile project team with the collection of accurate performance data.

What effect would the regulatory environment have on the delivery of projects?

One response stated that the regulatory environment can stall or delay the delivery of a project; this would indicate that the statutory requirements have to be taken account of in the planning and costing for the project.
Most of the responses reflected on the need to accommodate the State Departments in the planning and development of projects. Environmental Impact Assessments, Records of Decisions, Legislation, and Permitting all have to be taken into account at the initiation of the project.

Some of the respondents also examined the ongoing activity of the Department of Mineral Resources during the execution of mining projects. From here, in the experience of the respondents can come changes in legislation, work stoppages and large volumes of paperwork that can hamper the project execution and delay completion if not provided for and managed proactively.

How are ‘project failure learning points’ captured into the company learning?

Most of the respondents referred back to the lessons learnt processes of the company. It was noted by one of the respondents that these activities should not be just an administrative end of project process but should be a regular session to ensure the lessons learnt during project execution are remembered.

From the Client embedded EPCM response it was noted that there was a six monthly review of all of the current projects in progress to determine if all of the projects are delivering against the planning.

One of the respondents referred back to the company project review sessions but doubted the effectiveness of these sessions in capturing ‘lessons learnt’.

How do individual stakeholder objectives affect the project outcomes?

Most of the respondents reflected on the need to ensure all of the stakeholders are aligned and aligned to the project program at the start of the project.

One of the respondents remarked that this would not be a problem for the project if the project is well structured and there are ongoing checks and balances.

One of the respondents remarked that the stakeholders have to be advised of the project program impacts and that new objectives introduced will affect the execution program.

From the client group came the comment that the response that the stakeholders’ objectives should be considered during the initial scoping studies. In some complex projects there can be changes introduced by the new stakeholders brought into the project during execution.

What effect does poor planning have on project outcomes?

All of the respondents agreed that poor planning will have a huge detrimental effect on the project outcomes. Planning according to one is the backbone of the project.
One respondent discussed the detail of the effect of poor planning; the project execution team will be working blind should the planning lack the detail. According to this respondent the planning should be realistic and detailed enough to give the detail required for all the aspects leading to the success of the project. Planning will also guide the team regarding identification of poor contractive staff.

**What would you say are the main categories of project planning errors?**

Most of the EPCM group responses covered the normal planning errors:

- Missing tasks
- Lack of detail
- Scope changes
- Optimistic durations
- Incorrect logic
- No contingencies
- Poor team involvement
- Planner inexperience

The response from the client group expanded this with the following aspects:

- Underestimation of complexity
- Failure to manage expectations
- Poor granularity decisions, packages are too big
- Failing to gain commitment from all stakeholders
- Not prioritising the tasks to be performed
- Not providing time in the program for end user training
- Not providing for a process ramp up time in the program

Obviously the client group response provides for the ‘operationalising’ of the completed project which has not been considered in the EPCM program.

**Would a greater operational link for the project reduce the propensity for project failure?**

All of the respondents saw the value in ensuring there is an operational link in the project execution process and the reduced risk of project failure.

The operational link will give greater assurance that the client will get what they want.

One of the respondents stated that the links to the operational group from the client must be in place from the outset of the project, there is a risk that there will be a cost increase and some
program delays from this interaction but on the up side the client will get what they want and the plant start-up will be easier and less subject to rework.

One of the respondents reflected on the necessity to control the size and make-up of the operational stakeholder group.

The Client embedded EPCM reflected on the need for the EPCM to deliver what the client wants not what the EPCM wants to deliver.

### 6.9 Project success

**What defines the success of your project?**

In the responses to this question there was a clear difference between the client group response and the responses from the EPCM group.

The client group definition focussed on the implementation of the technology and achieving the desired and project outcomes for the project.

The EPCM responses reflected the efficacy of the project implementation strategy, in this regard the success factors were:

- Scope
- Program
- Quality
- Cost
- Safety incidents

One of the EPCM responses reflected on the definition of success from the point of view of the ECPM Company benefiting from the project experience:

- Team development
- Enhanced EPCM image

One of the respondents discussed the incremental success of the project in so far as the need to manage the perceptions of the client during certain stages of project execution.

**How is the project success measured and displayed?**

One of the respondents reflected on the project dashboard to display the key success criteria; packages completed, invoicing and progress and so on.

Most of the respondents examined the traditional project success factors time, cost and quality.

In the current EPCM and mining environment the safety performance is communicated within most of the client groups and within the greater EPCM environment.
In the Client embedded EPCM project successes are well communicated to the entire project team, these would include completed project packages.

The Client group response again reflected on the efficacy of the project and meeting performance objectives, achieving the time, cost and quality aspects of the project are taken as being a given.

**Has your project suffered from a disrupted program?**

All of the responses reflected on project disruptions.

Some were operational delays originating from the project region, i.e. Section 54 stoppages, industrial action, stop notes issued from the client or EPCM team.

Some were project environment stoppages; main contractor failures, client confidence induced delays (funding shortfalls), critical Board decisions on the project delayed, and client induced scope changes.

Some are International induced delays such as the economic crises and a fall off of international investor confidence.

**What was the nature of this disruption?**

There was as expected a diverse set of responses to this question. Many of the disruptions reported were centred on the provision of capital for the project; this was either to start the project or a capital preservation strategy during the execution of the project.

According to the respondent the capital preservation strategy from the client has impacted the funding for the key deliverable execution.

One of the responses reflected on the failure of the major contractor during the execution of the project.

One of the responses reflected on the late provision of electrical power to the project site by the state energy supplier.

**How can success be better assured in project partnerships?**

Most of the respondents reflected on the need for trust and common accountability between the project partners. The project partners have to be on the ‘same page’ during the project execution.

Common factors identified were; good planning, good communication, good coordination and project definition.

From one respondent there was the definition of shared responsibility, battery limits and the definition of key deliverables for each party to the project.
Are the ‘critical success factors’ an assistance to decision making?

Most of the responses to this question were in the affirmative seeing the critical success factors being a focal point for the project execution team.

One of the respondents stated that the critical success factors lack specific guidance for the project execution team for fully determining the project success.

What factors would you say are critical for project success?

Three facets were discussed by the respondents:

One of the respondents reflected on the EPCM mechanisms for project success; EPCM systems, skilled project managers, project team structure, suitable skilled personnel and adequate resources.

Other responses looked at the application of project tools for project success; schedule adherence, scope definition, deliverables understood by all. The project operating plan was identified as a factor in the project success; this links the engineering, procurement, quality assurance, fabrication, and delivery and/or construction aspects.

One of the responses looked at the client participation in the project success factor; participatory and supportive client, clearly defined project objectives and expectations.

What would you say are key contributors to success in an International environment?

Two aspects were identified in the responses; the aspect of the International EPCM and the aspect of operating in an International project environment.

Most of the responses reflected on the necessity to meld the International EPCM environment into a single entity.

Factors highlighted by the respondents included the following:

- Culture of trust, integrity and ‘making it work’
- Common project language – systems and standards
- Excellent communication and consultation strategy between all the parties
- Understanding of regional customs
- Team unity – roles and responsibilities clearly defined, with no gaps
- A common understanding – single version of the project requirements

From the client group response there was a reflection on the need for the project team to be versatile to be able to operate in an international environment. This response reflected on the cultural, business, community, markets and local government aspects of the International environment.
6.10 Conflict management

Has there been any conflict during the execution of your project?
All of the respondents responded in the affirmative regarding conflict on their project. Most said there were many incidents of project conflict in their experience. One of the respondents said the conflict in their experience was technical in nature. One of the respondents stated that the conflict was primarily with the client. One respondent stated that the conflict was significant.

What was the nature of this conflict in a project environment?
From the responses received there have been many causes for the conflict on the projects in question. There have been disagreements on the interpretation of specifications, certification and bonuses, contract interpretation, negotiations for presentation to the company board, blame allocation for failings, management changes in the client camp, personal differences, scope changes, and unclear responsibilities, conflicts between the client and the main contractors and disagreements in the execution team.

What are the main causes of conflict in a project environment?
This question was asking for an interpretation of the main causes of conflict. The responses were varied again. From the EPCM point of view the main sources of conflict in the project are differing interpretations in the scope, schedule, quality and costs. These are generally between the client and the EPCM contractor. In the execution of the scope there can be conflicts between the individuals as they can come from many various backgrounds and have differing levels of experience, and be working in a stress filled environment. Poor progress on the project and increasing costs can also lead to conflict between the client and the contracted staff. From the client and the EPCM contractor according to one response there can be conflict initiators from poor leadership, staff changes and poor communication.

How do you minimise the sources of conflict in a project environment?
One of the respondents stated that one of the key aspects to minimise conflict in the project is to have clear and thorough contracts in place. This would be coupled to good communication, transparency and fairness.

Another respondent stated that the conflict must be picked up as early as possible so that the effect of the conflict is minimised, and the conflict must be resolved speedily.

From the client group the response the key features for conflict mitigation were proper project initiation with procedure writing, proper project planning with sufficient detail, executing the baseline plan, managing the changes, monitoring progress and sound communication to the stakeholders.

From the EPCM group the respondent suggested that the interactions must be professional and as far as possible in writing and ensuring everyone understands what is required and expected of them. Also from the EPCM group came the comment that there should be regular alignment meetings with all of the stakeholders involved.

From the Client embedded EPCM group came the comment about the team structure and the need to keep the team together, well defined roles and responsibilities. Where specific team members are identified as not fitting in then these characters should be removed and replaced.

### What are the detrimental effects of conflict in a project environment?

All of the respondents agreed on this point.

The following terms were used:

- Demotivation, loss of morale,
- Loss of key personnel,
- Delays on the program, disruption,
- Strained communication,
- Breakdown of trust.

Obviously from the responses the conflict in the project has to be resolved as soon as possible as the ongoing conflict can be very detrimental to the project and detrimental to the EPCM company future.

### What are the positive effects of conflict in a project environment?

From the aggregate responses conflict can have a positive effect on the project team and indicates a positive buy-in to the project from the team members.

The positive aspects identified by the respondents were:

- Increased energy in the team
- Honest communication
• Issues aired and resolved
• Clears accountability
• Shows project commitment
• The contract gets reviewed
• People become experienced in identifying and resolving conflict situations

There was little disparity between the responses from the EPCM, Client and embedded EPCM groups.

How would you resolve conflict between two parties?

Most of the responses were text book conflict resolution techniques.

Addressing the situation not the personalities, identify the point of deviation and investigate, have a discussion between the parties, identify the actions to be taken, seek a compromise and a mutually acceptable solution and obtain agreement on the course of action.

The recommendation was that this is resolved as quickly as possible and the move on.

All of the respondents saw the two parties as individuals and not as conflicting companies of contractors. This in a mining project environment could be equally likely.

How would you arrive at a resolution?

Most of the respondents saw the way forward as being:

• All the conflicting parties to raise the points of conflict
• Agreeing the resolution points
• Agreeing a resolution strategy
• Institute a program or a review date to monitor the resolution and the close out of the conflict
• Ensure the resolution is the best for the team and the project
• Documenting the process for the future

One of the respondents discussed the mitigation and arbitration applied by the project manager in conflict situations.

What could be source of conflict in a global project in the design phase?

The respondents saw the conflict occurring from the traditional sources in global projects with aspects such as:

• Lack of understanding of the requirements
• Differing technical standards and in-house design rules
• Communication and time differences
• Language and cultural differences
• Differing personalities
• Team alignment to the project goals
• Packaging of the scope and estimating the resources required
• Differing responses to change and differing criteria for satisfaction

What could be source of conflict in a global project in the construction phase?
One of the respondents examined the project environment as being a source of conflict with such issues as project climatic conditions, licensing constraints, materials and logistics and information flow constraints.

The other respondents examined the traditional EPCM points of conflict; engineering – construction site conflict, late delivery of information and specifications, contractor conflicts on site, communication and culture barriers, health and safety practices (of particular importance to International EPCM companies), local legislation, conflict between the contracting companies on site due to cultural differences, delays in decision making.

On top of this according to one respondent was the gap between the client expectations and the expectations of the EPCM/Contractor.

How would you manage conflict in a global project?
There was a wide variety in the responses to this question; one of the respondents saw no difference to the management of global conflict as to local conflict.

One of the respondents saw the need to catch the conflict as early as possible and to gain consensus from the senior management as to the processes to be followed and the necessity to gain an early resolution.

Three of the respondents saw the necessity to gain an early consensus on the way the project will be managed and the project standards to be followed. One of the respondents identified the need to develop a mechanism for dealing with conflicts and means to address the predicted communication barriers.

What is the influence and effect of global procurement on project failure?
Most of the respondents saw the financial and logistical challenges in global procurement. The logistical challenges according to some of the respondents would introduce unfamiliar challenges to the procurement processes particularly regarding the delivery of material to site on time so as not to impact the project delivery.
Some of the respondents reflected on the language and cultural barriers that global procurement would introduce.

One of the respondents reflected on the need for good quality control and the need to build up a sound supplier list based on experience and trust.

One of the respondents stated that there would be no negative influence providing there is good and experienced management in this area.

6.11 Project management philosophy

Why do you think project management principles have become widespread in industry?

Most of the respondents reflected on the establishment of a common project language and the alignment of expectations, and a means of delivering the required outcome.

One of the respondents stated that project management principles have been proven over time and give an assurance of project success.

Yet another respondent reflected on the past project failures and that the industry needed some guidelines to give an assurance of project success.

One of the respondents stated that at some time the project management principles have been proven to be ineffective and strained and that the project management principles have to be practised judiciously.

Why do mining projects generally have significant overrun on costs and schedule?

The respondents reflected on the inadequate knowledge of the ore body at the inception of the project and the overenthusiasm of the mining engineers interpreting these results and developing a recommendation for the ore body. There could also be, according to one significant biases introduced during the feasibility studies to improve the perceived value of the project to gain funding.

Respondents also reflected on the long duration of the typical mining project and the changes that can occur in the project environment over this period. Changes would include changes in the; execution team and the client group. For the external environment there could be changes in the metal prices, legislation, environmental requirement and exchange rates.

During the project execution according to one respondent there could be inexperience in the execution team, over stretched resources (required to work on other projects) and real logistical constraints. Though these are valid concerns they should be picked up early in the project execution and could be addressed.
Also during execution according to one there could be labour unrest, legislative delays and unforeseen detrimental geotechnical features.

**Is the PMBoK® way fully applicable to long term mining projects?**

Most of the respondent agreed that the PMBoK® way is applicable to the execution of long term mining projects.

A majority said in their responses that either this had to be applied judiciously or that some features needed to be added.

One of the responses stated that most of the aspect of the PMBoK® applied to the client’s goals for the project some would be less applicable.

The response from the client group stated that the PMBoK® system was not applied but that it was an industry standard.

Yet another response from the EPCM group stated that the unique feature of the long term mining project was that there is a strong influence from mining legislation and the mining operational activities that are not accounted for in the PMBoK® guidelines.

The Client embedded EPCM group stated that the PMBoK® guidelines had to be reinforced with some specific management tasks in safety, contracts, engineering, environmental and construction to increase the relevance.

**6.12 Last planner**

**What detail of planning is in place at the start of the project?**

The respondents reflected on the increasing level of detail in the project planning as the planning developed from the concept study through the pre-feasibility and feasibility studies.

One of the respondents stated that at the point of execution there is a requirement for a ‘level 5’ schedule giving resource loading for the project. Another respondent stated that there should be an allowance of 1 to 2 months to set up the project before the work on the project commences.

One of the respondents stated that there is typically not enough detail in the planning at the start of the project. The requirement should be level 5 or 6 at the inception of project execution.

One of the challenges as noted by a couple of respondents is that at the inception of the project is that the contractors planning is not available, these plans would only become available once the contracts are awarded and the project is in execution. Often the plans a project initiation are still the optimistic board approved plans.

The response from the client group was that at the start of the project the project has the desktop study and that the accuracy of this planning is low, with 50% accuracy for capital and timing.
What time planning horizon do you look at?

Various responses were received from the respondents.

One of the respondents looked at six planning horizons from 10 years to one day for long duration projects. Another respondent looked at the financial year with a refinement to the procurement lead times, lapped on to this was the window required for the development of the drawings, procurement scopes of work and specifications.

From the client group came the response looking at 30 to 50 year conceptual expansion plans, five year rolling operating plans, one year technical plans and finally a detailed monthly plan.

Most of the EPCM responses appeared to reflect the general rules established by the client preferences for planning; this was one of the major tasks that reflected the client preferences.

From the Client embedded EPCM group can the rolling and detailed annual planning.

Do you have a buffer of tasks for the design or construction crews?

Most of the respondents acknowledged that there is a buffer of tasks available for the construction teams but that this is not necessarily a planned buffer.

One of the respondents stated that there is usually a surplus of sites available for the construction teams to access on a particular level.

One of the respondents indicated that due to the project pressure there is no buffer of tasks for the construction teams. According to another there is too much pressure on the project cash flow to provide a buffer of tasks as the equipment required would not be available for the construction team.

How do you monitor the task completion performance on your project?

Most of the respondents reflected on the monitoring of the task completion by the resources available on site such as the supervisors and the site engineer. These persons would record the completed tasks and monitor the completion against the project plan.

The planner would record the task completion against the project plan. The task completion would be reported in the progress meetings.

One of the respondents discussed the need to monitor the performance of task completion against the resources and hours that would be required against the planned resources and hours.

The embedded EPCM group indicated that there is greater performance measuring and reporting regarding program and discipline performance. This is then reported back to the client structures through an indicated reporting format and structure.
How does the ‘Last Planner’ facilitate the project?

Some of the respondents had no concept of the ‘Last Planner’ process and technique. Some of the respondents had heard of the last planner process but had not implemented this technique on their project. Most of the respondents that understood the system did not have the repletion of resources necessary to implement the last planner system. A few of the respondents understood the process of increasing planning clarification as the rolling planning nears the task execution phase and the last planner is there to add the detail into the execution plan. One of the respondents commented in the updating of the master schedule with the details from the sub-schedules and the information from the weekly progress meetings.

6.13 Agile project management

What is your definition of a project?

Most of the EPCM responses reflected the standard text book definition of a project, to wit the:

- Defined series of activities
- Defined budget
- Defined start and completion date
- Defined objectives
- Application of project principles

The response from the Client group added the ‘system or process that if implemented will add value to the company’.

What would you understand by the term ‘agile project management’?

Most of the respondents understood the intent of agile project management. One of the respondents stated that it was the ability to compromise and the ability to work around. Most of the respondents identified the flexibility of the project team and the ability to respond in good time to the changing demands and requirements of the project in execution. This would also include the ability to respond to the changing project environment. One of the respondents reflected on the less structured project environment, the less clearly defined scope, and the less clearly defined delivery system for the project. The final comment from this respondent was the necessity for this approach to be accepted by both the project execution team and the client.
The Client embedded EPCM was not familiar with this technique for project delivery.

**What would you see as being the advantages of agile project management?**

Most of the respondents understood the advantages of agile project management particularly in a long term multidiscipline mining project environment.

It was acknowledged by some of the respondents that the mining project is seldom clearly defined from the outset and this would require ‘greater innovation’ in the project execution techniques.

From the client group it was noted that the design is done incrementally and with the longer duration new technologies can be included in the implementation of the project with an agile execution team.

One of the respondents stated that agile project management will allow execution in the dynamic project environment with minimal effect on the program and cost.

Another respondent stated that the project environment is ever changing and the project execution team should manage projects in a similar manner.

**What would be the requirements for implementing agile project management**

Most of the respondents reflected on the requirements for the project execution team and the acceptance from the client for the necessity for an agility focussed project team.

With regard to the project execution team, there was a general consensus on the need for a well experienced project execution team and the understanding of the team for the need for agility. The team must be capable of accepting the circumstances of the project and be capable of accommodating the requirements of the project.

The response from the client group and one response from the EPCM group reflected on the dynamics of the project requiring an agile approach from the project execution team.

**When would the use of agile project management tactics be advantageous?**

Most of the respondents reflected on the project environment being uncertain execution program and having a changing scope. Some also reflected on the project external environment being uncertain or volatile.

**What would be the basic tools of agile project management?**

There was general agreement on the need for good project management skills and a good understanding of the changing project scope.
There were a few of the respondents who noted the need for good communication skills. The EPCM would require systems that are amenable and flexible with regard to the changing features of the project.

One of the respondents stated that the team must be versatile and experienced, and the client amenable to the agile approach to project management, this would reflect on the reporting and management aspects of the project execution.

From the client group the response reflected on the agile approach reducing the complexity of the project and need for planning throughout the project rather than just at the outset of the project.

**Why would improvisation be a prerequisite?**

Most of the respondents reflected on the circumstances when the project scope or program would change unexpectedly, this would require a team that could accommodate this change, work around the challenges and deliver a solution to the client.

The client group response reflected on the breakdown of the tasks into a series of smaller tasks that can be executed in an adaptive and improvisational manner rather than in the classic pre-planned manner.

**What would be the role of improvisation in project management?**

Most of the responses received viewed improvisation as the technique of being able to adapt to sudden changes during project execution. This would minimise the effect of this change on the project execution program.

One of the respondents saw this as an opportunity to think out of the box, the opportunity to apply novel techniques in project execution.

From the client group the response was more academic with a definition of intuition as a cognitive conclusion based on previous experiences and emotional inputs.

One of the EPCM group responses saw it as changing what is to be done to match what has been done.

The key in this question was the application to both technical and management aspects of project management.

**What would you see as being the challenges of agile project management?**

Most of the respondents saw the challenges as being the project team and the communication within the project team.
Respondents saw the necessity for a mature project execution team, work in an environment that is not over proceduralised and a well-integrated team. One respondent stated that not all project management teams would be suited to agile project management.

The team would have to work closely together and this would to a certain extent preclude globally based teams.

The necessity, according to one respondent, for fast and liberal communication strategies would be essential for agile project management.

The response from the client group was that this project management technique did not seem suited to the mining industry related projects.

From the Client embedded EPCM the general response was one that there was no understanding of agile project management.

From the EPCM group of responses came the caveat that things could be overlooked in the agile processes so there would be a necessity for additional checks.

**6.14 Project systems**

<table>
<thead>
<tr>
<th>Does the company adopt project management principles throughout the entire company?</th>
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<tbody>
<tr>
<td>There was a mix of responses but the consensus from the EPCM group was that the company does not do this. The not project resources would be run in accordance with the best practices for that department.</td>
</tr>
<tr>
<td>One of the respondents stated that the project teams are selected from the matrix structures that proliferate in the company and the support departments are not seen as being part of the project delivery process</td>
</tr>
<tr>
<td>Two of the responses were emphatic no’s. Two were yes’s.</td>
</tr>
<tr>
<td>From the Client embedded EPCM there was a response to say that within the client organisation there was no adoption of project management principles but within the EPCM company there was an impression that the company was moving in that direction.</td>
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<table>
<thead>
<tr>
<th>What would be the benefits of the EPCM Company embracing a project management methodology in all aspects of the business?</th>
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<tbody>
<tr>
<td>Most of the respondents saw the benefit of applying project management principles across the company.</td>
</tr>
<tr>
<td>Generally, there would be a greater understanding of the business of the company and all of the departments could be seen as contributing to the greater business of the company and contributing to the project delivery. There would be a favourable consequence of the EPCM</td>
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</table>
Company becoming more efficient and effective in all aspects of the business, the company would be speaking the same language across all aspects of the business.

The response from the client group saw this as giving the clients a greater confidence in the products and processes of the EPCM Company.

The response from the Client embedded EPCM did not see the application of project management principles in non-project based centres of the company.

6.15 Project control in uncertain environments

How would you define project uncertainty?

Most of the respondents saw project uncertainty as being uncertainty in the three aspects of the project:

- Scope
- Delivery
- Program

The response from the Client group saw project uncertainty as incomplete knowledge, or where the extent of the impact of known factors cannot be calculated.

One of the EPCM group responses stated that uncertainty is a lack of clarity regarding the work that is required and the goal of the project is not clear.

Another EPCM response uncertainty being more of an operational in process lack of clarity, and this is compounded by poor communication and poor planning.

The Client embedded EPCM response examined the compromising effect on the project in execution by client originating influences such as a cut in the project budget, significant scope changes or the mid-term changes in one of the principle contractors on the project.

Ambiguity is seen to be a cause of uncertainty, what do you see as the drivers of uncertainty?

Most of the EPCM responses indicated that the Client is the principle driver of uncertainty in the project environment.

The client could be:

- Uncertain of the requirements, lacking information to make an informed decision
- Wanting to keep options open, to change the definition of the project
- Not providing adequate leadership or direction to the project

According to the Client group respondent there could be a particular task that is engendering the uncertainty in the project.
One of the EPCM group responses said that there could be an information glut or excess, the inability to make decisions or inadequate communication driving the uncertainty.

From the Client embedded EPCM group came the response that the efficient project team has clear goals and a well-defined program. When the project goals change or there is a disturbance to the program then the project team feels threatened then the efficiency of the team is lost and package completion is threatened. The recommendation from this is therefore not to allow the project to become disrupted.

**How would uncertainty affect the decision making process within the project?**

Most of the respondents from the EPCM group saw the uncertainty as being a driver of not being able to make a decision or poor decisions being made with inadequate information. According to one there was a risk that a poor decision could be made in this circumstance.

According to one the client would be unable to make a decision and this would devolve down to the EPCM who would lack guidance. According to another there would be a requirement for the client to provide the definition for this aspect of the project.

From the Client group came the necessity to make a decision based on the information that is to hand and a risk assessment to be performed evaluating the impact of the unknowns. According to the Client group response, this is common in the mining industry, incomplete information about the integrity of the ore body was cited as an example.

One of the EPCM group responses recommended that the project execution team focus on the completion of the tasks where the information is available and wait until there is clarity on the unknown aspects.

**Is the traditional matrix environment appropriate in an uncertain and turbulent environment?**

One of the respondents remarked that the project team has to work as an integrated unit and that this would not be dependent on the matrix structures within the company.

This was reflected by another respondent who remarked that the Project Manager is the key player in the team and it up to the Project Manager to ensure the team acts as a unit under the Project Managers direction.

The other respondents remarked that the matrix structure with in the EPCM Company would act in various ways to support the project execution team. The respondents reflected on the smoothing of resources, providing visibility for the team members within the greater organisation, allocation of resources should the project fail, and providing a peer review group for direction and consultation.
The Client embedded EPCM group reflected on the provision of Head Office support functions such as training and development. The Project Manager has the function of directing the project team in the day to day functions that relate to the project deliverables.

How does senior management respond to increasing levels of uncertainty?

In general, the respondents remarked on the Senior Management being more frustrated as the project trends into uncertainty. This was generally associated to the increasing risk associated with an ‘uncertain project’. This, according to two of the respondents, affected the assurance of revenues from the project.

One of the respondents reflected on the propensity for Senior Management to become involved when the project is perceived to be in trouble, to give clarity to the project inn execution.

One of the respondents reflected on the need for Senior Management to become involved with the client to identify the causes of the project uncertainty.

One of the respondents stated that in the period of uncertainty there is an opportunity to generate more income from the additional work. Should however the uncertainty be a result of the actions of the EPCM there would be a need for additional involvement from Senior Management.

From the Client embedded EPCM there was a note stating that Senior Management should be open and honest regarding the causes and effect of the uncertainty. The team is often remote from the Head Office activities and sentiments. Because of this they rely on Senior Management for clarity and direction.

How does senior management view and react to deviations from the established project plan?

There was a variety of responses to this question.

Some of the responses reflected on the unpredictability of the project and the need to explain the deviation from the project plan. Deviation to the established project plan make resourcing of the project more challenging, and the billability of the allocated resources less predictable.

Some of the responses stated that this is a common feature of projects and that changes are inevitable. There are processes in place for the management of change.

One of the respondents remarked that the Senior Management being remote from the project reacted with a ‘big stick’ approach.

The Client embedded EPCM remarked that the Client tries to avoid changes to the established program understanding that this can have a serious ‘knock on’ effect on the project execution team.
How does the project team react to increasing uncertainty in the project?

In general, the responses received reflected on the loss of interest, demotivation and reducing efficiency of the project execution team.

Increasing uncertainty causes security concerns amongst the team. According to one respondent the project team often does not have a full understanding of the project and the immediate project environment and thus cannot find solace in the uncertain project environment.

One of the respondents reflected on the individuals in ability to plan the tasks for the day in an uncertain unpredictable environment. The increasing demands for innovation and agility may not suit all of the personnel on the project.

How does your management style change in an uncertain environment?

The general response received was that more time had to be allocated to communication with the team and more time taken to consult with the client. Team meetings have to become more frequent so that the team can hear something even if there is nothing to say.

According to some the team has to be focussed on the project deliverables and executable tasks.

The communication with the client and stakeholders has to be on finding solutions to the uncertainty and sharing the risk of the execution strategies.

Two of the respondents reflected on the ever-present uncertainty in mining projects, and one that would have to become more direct and decisive in times of project uncertainty.

The Client embedded EPCM reflected that management should focus on risk management and the development of scenarios and action plans.

6.16 Managing multiple projects

How would you describe a ‘multiple project environment’?

Most of the respondents understood the basic philosophy of a multiple project environment.

Some of the respondents saw this as multiple project within a single project, some saw this as one office managing more than one project, some saw this as one project manager managing more than one project.

One of the respondents envisaged the complexity of managing multiple projects for one client and the added complexity of managing different project for a variety of clients.

The response from the client group did not see the variety of client and the response from the client embedded EPCM did not see the multiple project environment of the mining industry.
What challenges does running multiple projects present?

Most of the respondents saw the added complexity of running multiple projects with a wide group of stakeholders. This would, according to one respondent make the allocation of resources challenging:

- Multiple schedules
- Multiple stakeholders
- Resource management
- Complex structures

Some of the respondents stated that the running of multiple projects would be a challenge and that a project running into difficulties could go unnoticed (loss of focus), the multiple project environment could place undue demands on the execution team.

A positive aspect identified by one of the respondents was that there could be a work preservation aspect; one project may be heading for a quiet period whilst the other could be ramping up in demands.

What are the problems related to managing multiple projects?

Most of the respondents remarked on the prioritising of the time to be allocated to the management of the various projects in the portfolio. Coupled to this according to one respondent was the application of uniform standards across the various project, this would be compounded by the project being with different clients with different requirements to be satisfied.

Another respondent remarked on the personal coordination required to manage the project effectively and the optimal allocation of resources.

From the client group, this situation was largely unfamiliar and the multiple projects were seen as a sequential group of project where the concluding project was an input to the next project.

One of the EPCM group respondents stated that it would be necessary to review the projects in execution holistically to establish and maintain the correct focus on the projects.

How does the company structure support managing multiple projects?

The consensus of the responses was that the company does not have the necessary procedures to support the management of multiple projects by one project manager.

The EPCM Company has a matrix type structure that is geared to allocating resources to the project. The HoD’s according to one respondent have free rein to allocate the resources to the projects as they see fit.
The response from the Client group was that each department has representation in the project execution team.

One of the respondents reflected on the Portfolio Managers/Project Sponsors who have the responsibility to oversee multiple projects with multiple project managers.

Most of the respondents did not see that the management of some large projects requires the Project Manager to view the project as a multiple project.

**What are the key aspects for companies managing multiple projects?**

The majority of the respondents saw the necessity for a good and well-staffed resource pool to be able to effectively staff the projects, and HoD’s who are involved in the processes.

There is a necessity for good communication and flexible uniform systems that cater for a variety of client’s needs.

Communication must be effective and thorough.

The response from the client group reflected on the need for project managers that can adapt to different teams and key drivers quickly and effectively.

The client group response also remarked on the flexibility and versatility of the project execution team to be able to handle the pressures, differing priorities and initiatives.

One of the respondents remarked on the need for the company to be able to manage each of the projects as an individual entity and not as a collective entity.

The response from the Client embedded EPCM was one of caution, being able to say no when necessary and to have mature systems through the company including HR and Finance. This would presumably remove this aspect from the concerns of the project manager.

**6.17 Relational Contracting**

**What do you understand by the term ‘relational contracting’ in a project environment?**

There was a variety of response to this question that indicated that the term was appreciated if not fully understood.

One of the respondents saw the necessity for developing a good contracting relationship between the client and the main contractor particularly where there will be a need for ongoing support during the project execution period.

One of the respondents saw the mutual benefit of a relationship with there being a contract in place.
The response from the Client group saw the relationship between the contracting parties being more important than the terms of the contract with the mechanisms for delivery that focus on the trust and partnering. One of the responses stated the contracts are based on trust.

The response from the Client embedded EPCM stated this was not a familiar term.

What is the value of relational contracting in a project environment?

Two of the responses saw the benefit of relational contracting, but that this would require the full support from the client.

An example cited was the requirement for on-going original equipment supplier support for plant and equipment that is going to be used for the execution of the project scope. This could be for spares, technical support or on-going consultancy.

One of the respondents saw that the work and the outcomes become more valuable than the contract.

There was a need for a good contracting environment to be in place for the relational contracting environment to work well.

How would you interpret relational employment in a project environment?

Most of the respondents did not understand this term in the light of the previous question.

Two of the respondents saw this as the employment of contract staff or consultants where there is not a full time requirement for these resources on the staff of the company or the EPCM. One of these respondents saw this as a pool of external resources that are not employed directly by the EPCM but are available to supplement resources as required by the contracted work.

This could also be extended to the relationship with the OEM regarding technical support.

This would be similar to the sourcing of an EPCM company by the Client.

How would you interpret relational outsourcing in a project environment?

Some of the respondents saw this outsourcing of a specific package to an external resource, particularly of a task that would normally be done by the EPCM Company. An example cited was the outsourcing of a pump station design package. The term 'commodity outsourcing' was raised.

One of the respondents raised the use of a consultant to do certain aspects of the project based on previous experience with this supplier. The consultant would have certain knowledge or proven expertise required by the project. Examples cited were transport studies, or material movement and logistics studies.
6.18 Fast-tracking

What is your interpretation of the term ‘fast-tracking’?

This term was generally well understood by the respondents.

Respondents saw this as compressing the project delivery time line, crashing the program, removing the slack time or fat from the project schedule.

One of the respondents saw this as carrying out tasks concurrently/ parallel and applying a ‘design as you go’ strategy.

One of the respondents applied the strategy of adding resources or adding shifts or working longer hours to complete the tasks to hand. Another saw the benefit of overlapping or performing tasks concurrently to reduce the execution time.

Why are projects fast-tracked and what are the benefits of fast-tracking?

Most of the respondents saw that this strategy is to either bring the returns earlier for the benefit of the client or to catch up on a lagging program.

According to one the fast-tracked projects can save a project in a failing project environment.

One of the respondents reflected on the early availability of major assets for the project that can be utilised for the completion or development of other aspects of the project.

Most of the respondents saw that the fast-tracking can bring earlier returns for the client that may improve the business case for the project. Fast-tracking will, in most cases incur a cost that will have to be defrayed against the improvement in the returns from the project.

According to one of the respondents there could be a project opportunity that has to be taken as it occurs.

What risks does fast-tracking induce in the project?

Most of the respondents saw the additional cost associated with fast-tracking, this would be due to the inefficient allocation of resources and possibly the less efficient use of materials.

Some of the respondents saw that there could be risk that quality could be compromised due to the saturation of the resources allocated to the project. There would also be a risk to the integrity of the design, either due to incomplete information, not all of the design aspect being considered and some of the future aspects not being included in the design input information. According to one there would be a contingent risk of rework.

One of the significant risks in the long term mining project environment would be a safety risk resulting from the over allocation of project resources.
According to the Client embedded EPCM there would be an increase in the project execution complexity as tasks would be running in parallel.

How would you attain early revenues?

According to some of the respondents there would be an opportunity to gain early revenues from a section of the plan being available to the client operations and be in a position to earn revenues or to defray some of the investment costs. The completed section of the plant could be used for the completion of the remaining scope of the project.

The Client group response saw that there was a necessity to carry out proper planning; there would be an opportunity to obtain early revenues from the project or prototype plant prior to the main section of the plant being completed.

One of the respondents indicated that though there are opportunities from fast tracking the changes to the design or the execution program could have a negative effect of affecting the overall plant efficiency and long term returns.

6.19 Large multidiscipline mining (LMM) projects

How would you define an ‘LMM project’?

Two of the respondents attached a value to the LMM project; greater than USD100 million (ZAR1 billion), or according to one ZAR2 billion).

Some of the respondents attached a long duration to the LMM project; one stated more than three years.

Most of the respondents attached a complexity to the project to differentiate the LMM project. One mentioned the surface and underground activities; another mentioned the aspects of the LMM project both surface and underground infrastructure and a metallurgical plant.

In general, there was a cost aspect, duration and a project complexity in both underground and surface activities.

How do you see the future of the LMM project?

Some of the respondents regarded the esoteric aspects of the LMM project. The high cost project according to some reflected on the difficulty in obtaining finance for these projects and the reluctance to place one holistic project with a single EPCM group.

Other responses review the growing shortage of capital for these projects, the gradual exhaustion of the easy and payable ore bodies and the renewed propensity for the mining companies to
exploit ore bodies the can be reached easily with existing systems and also through the development of decline shafts.

According to one respondent the mining companies would be reviewing the use of existing assets. According to some there would be a renewed interest in the exploitation of the lower grade orebodies, this would require an EPCM that is aware of this process and take full responsibility.

**What are the pressures resulting from LMM projects?**

There was a variety of responses to this question; one reflected on the pressure on the execution team (from both the Client and the EPCM) and the possibility of project fatigue, one reflected on the lower revenues and the higher capital costs.

One of the respondents looked at the project duration aspects with multiple contractors, changes to the project scope and aspects such as recessions affecting the funding confidence.

LMM projects can result in there being a large number of deliverables for the project.

The value of the LMM can be linked to the commodity prices; this may vary over the duration project and into an operational mine.

The EPCM has to ensure that the value of the project to the client can be continuously evaluated whilst the project remains in execution.

**What are the challenges of LMM projects in the virtual project house?**

One of the respondents reflected on the future of the EPCM existing in the virtual project environment and that this technique would have to be practised and complimentary systems developed and entrenched.

The response from the Client group reflected on the risk and uncertainty being higher with the virtual project house environment.

One of the EPCM responses saw that there could well be a challenge in maintaining the project team in this virtual environment. Other project team activities such as knowledge sharing and recording lessons learnt would be a challenge to the virtual project team.

Another respondent reflected on the greater need for communication and that not all team members would react well to working in the virtual office.

A respondent did not see anything exceptional with this concept, there would however be a necessity to bring the resources together in this dis-jointed organisation. This was reciprocated by another respondent who was concerned by the greater need for staff retention for the project and the necessity to put together a staff retention strategy.

Whatever strategy is undertaken then there would be a necessity to convince the client that this approach will work and be cost effective.
What are the favourable trends in LMM projects?

One of the respondents saw the Junior Miner looking more towards the ECPM Company for the project execution resources that they do not hold in house.

Some of the clients according to one respondent focus on the core business of the company and look to the EPCM for resources they do not hold. From the EPCM point of view the LMM can be a flagship project and can provide an element of stability.

One of the respondents stated that the LMM project can provide an opportunity for EPCM Company to test the aspect of design reuse and other cost reducing exercises. In addition to this some of the Clients are splitting the packages amongst several of their approved EPCM companies.

The response from the Client embedded EPCM was that the stand alone EPCM would fade away in preference of the 'owner managed integrated' team. Key resources would be taken over by the client into the client organisation giving the client a greater control of the output of these resources.

6.20 Project safeguards

What do you understand as being a ‘project safeguard’?

There was a variety of responses to this question.

Most of the respondents saw this as a risk mitigating activity within the project; be it a risk mitigating strategy, a contingency, insurances, a fall-back position, project schedule float.

One of the respondents saw this from the EPCM point of view in terms of allocating your best resources to the project to safeguard the execution process to give greater assurance of project success.

One of the respondents saw this from a design and execution point of view; building in project safeguards that will give the client either options for future expansion or building in the options for early returns during the project execution.

Why would a project safeguard be required?

One of the responses saw this as providing the client with a greater assurance of project success, the size of the investment in the project and in one EPCM Company is significant and the client should be assured of success.

The response from the Client group was from the point of view that the essential aspect of project management is to be able to identify the hazards and to have the safeguards in place to manage these hazards.
The other safeguards envisaged by the respondents were to protect the EPCM and the Client from potential claims, and to provide a source of funds and project execution time to ensure the project can be completed without claims, overruns not budgeted for and within a reasonable time period.

One of the respondents saw the necessity to provide early revenue for the project owner and to provide the opportunities for future expansions thus improving the viability of the project.

**What would be an example of a project safeguard?**

One of the respondents saw the necessity for the client to select the best and most compatible EPCM Company.

One of the respondents saw the benefit of setting up a good joint venture with a local partner as a project safeguard.

Another respondent saw the benefits in peer reviews and a risk analysis of the program. Yet another respondent mentioned the delay damages and the use of performance bonds. Another saw the safeguards in the budget contingency and forward cover.

Finally, one respondent saw a safeguard in the early use of plant, building in reserve capacity in pumping and electrical reticulation and the planning a provision for future expansions.

**What would be an example of mining project safeguard?**

The responses received were similar to the responses reviewed above. This was as a result of not understanding the original concept of a project safeguard.

One of the respondents saw this as the planning of development underground to accommodate future expansion of the mining footprint and providing for future declines.

One of the respondents saw the necessity to protect the project against corrupt and/or illegal activities and the investment protection agreements.

From the local environment, one of the respondents saw the necessity for planning for thorough and complete compliance to mining legislation to avoid as far as is possible conflict with the Department of Mineral Resources.

Another respondent saw the value in audits of the quality management planning for the project.

From a practical point of view, the Client embedded EPCM saw a mining project safeguard as being the establishment of second exits in mining projects.
6.21 Estimating

**What would you say are the challenges presented by estimating on a ‘Mega Project’?**

Two of the respondents saw the complexity in the number of quoted required in a short space of time and that there could be a number of companies requiring the same information from the same vendors/suppliers.

The response from the Client group saw the challenges in the up-front aspects of the design, the granularity, identifying the dependencies and poor scheduling. Coupled to this would be the poor estimating techniques and over tasking the project team.

Another EPCM group respondent saw the accuracy of the input data could be suspect and errors could creep in in the estimation of the quantities and rates.

Contingencies could be challenging to determine and the derivation of an acceptable escalation metric with the client would be a sticking point in the negotiations.

**What would you say makes for successful estimating?**

One of the respondents identified the need for sufficient time and the correct nature and quantity of resources required for the estimating process. This was reflected by another respondent commenting that there should be sufficient time and there is a necessity for the accuracy of measurement of quantities.

The response from the Client embedded EPCM was that there should be a well and accurately defined scope, this is often lacking in the CBE phase of the project when the Client is often impatient to provide a project budget. In this phase according the Client embedded EPCM the engineering should be taken to the best degree of accuracy. There should also be, in the EPCM the ability to benchmark the project estimates against running projects – there should also be Peer reviews from teams in similar projects.

From the EPCM group came the response that the project should be clearly defined, and the scopes for tendering should be as clear as can be obtained in the time available. What is put in in this time in the project evolution is what you will get out.

The response from the Client group highlighted the need for sufficient time to be made available to generate a realistic and representative definition to the project. This would allow and encourage the companies to be accurate in the estimating and give them the confidence that the project is likely to proceed from this phase into execution.

**What effect can the surfeit of projects have on the estimating process?**
Most of the responses received reflected on the process of vendor fatigue, vendors become aware that the tenders are for a CBE process and have little chance of becoming orders or formal quotations in the near future. Thus little effort is placed in the estimating process.

One of the respondents expanded on this line of thought stating there could be a process of tender biasing taking place and the apparent cost for the package could increase in this process.

As remarked on by the Client group response, the accuracy of the estimate and the CBE is reduced.

Two of the respondents stated that this surfeit of project becomes a good opportunity to build a broad and recent data base for other projects following the same process.

What responses can be expected from the vendors?

One of the respondents reflected on the current workload and shop loading being experience by the vendors, in this time you could expect a good response from the tenderers as they are looking for work.

In general, though the consensus was to expect an element of vendor fatigue to set in as the vendors receive the requests to quote from a few companies, this would result in more and more ‘cut and paste’ efforts being received.

From one of the respondents came the reply that there could be a developing apathy and the responses could become standardised.

In general, the responses received were consistent indicating that the costing could become inaccurate and generalised. This could result in the costing escalating as vendors seek to defray some of the costs incurred by them in providing these estimates.

Where are the sources of bias and error in estimating?

The responses from the EPCM group looked at the reduction in the accuracy of the estimates as the vendor looks at managing a multitude of quotes. Where the information from the EPCM is lacking in clarity and definition, this is reflected on the pricing as vendors’ factor in an element of risk and uncertainty.

From the EPCM group came the response that there are many factors that can affect the estimating process, not least of which would be rushing the process to a conclusion. Not least amongst this were the clear scope definition and the compression of the estimating process. There was also a response that looked at the pressure being placed on the estimating team as being a stress inducer on the estimating team.

One of the respondents reflected on the need to use reliable vendors who will submit a tender and will not seek to load the pricing for the package. In the same vein was a response the vendor
would under-price in the hope that they will be better positioned to secure work on the project in the near future, this sentiment was reflected in a couple of responses to this question.

**What is the effect of cost overruns on the project execution?**

Most of the respondents reflected on the negative effect of cost overruns on the project, this was expanded with comments such as:

- A negative effect on the funding for the rest of the project as the client attempts to remain within budget for the project
- A requirement to go back to the Board to secure additional funding for the rest of the project, pressure on the owner funding
- A negative effect on the viability of the project, worsening business case for the project
- Possible delays in the project completion
- Reputational damage for the Client and the EPCM
- Funding only available at a high cost

**Why would you say there is a trend to underestimate during the feasibility study?**

This was one of the pivotal questions in the question set.

One of the respondents stated that due to the scarcity of funding the pressure is on the team producing the CBE to understate the costs and sort out the overruns in the execution process. Another respondent discusses the competition for funding particularly with the ‘Junior Miners’.

The response from the Client group was in a similar line, the need to show the best possible returns for the project, the assumptions and design criteria used in a study are the most optimistic.

A response from the EPCM group stated that there was uncertainty in the final scope and execution plan. Another response from this group stated that the client uses the project uncertainty to improve the project NPV and IRR to obtain the project approval.

From the Client embedded EPCM came the comment that there is insufficient time to carry out a detailed design in the CBE phase of the project and the teams have a subconscious desire to see the project go ahead.

One of the responses from the EPCM group disagreed with this statement.

**Why would underestimation persist?**

The Client embedded EPCM did not fully understand this question so no answer was tendered.

From the EPCM group came the response that this was a general trend in the industry and that this drives and perpetuates the underestimation culture, linked to this culture was one where the
risks are suppressed and the returns inflated to improve the apparent viability of the project and secure funding. The final comment from this respondent was that the financiers should apply their own correction factor or contingency to these studies.

Also from the EPCM group came the response that there is a continual biasing of the CBE because there is always a competition for the finance for these projects and that is this factor that continues the underestimation psyche.

Other respondents disregarded the team biasing and saw the challenges in the time available, incomplete design criteria, poor scope definition and the need to create work for the EPCM Company.

What do you understand of the term information asymmetry?

Most of the respondents saw this as an imbalance in the information presented. This can be either subconscious or deliberate.

One of the respondents reflected on the information retention by the engineering team to the project financiers. This can be done to present the project in the best possible way the financiers. The information presented emphasises the strong aspects of the project.

Other respondents did not see this just in the CBE phase of the project, information asymmetry can occur at any time, but is the selective divulgement of information to support a particular point of view, unbalanced sharing of information.

The response from the Client embedded EPCM was that this term was not known.

Is cost underestimation prevalent in both small and large projects?

Most of the respondent saw this in both big and small projects. In general, however they saw that it would have greater significance in the larger project than the smaller project for a variety of reasons.

One of the respondents saw that scale of the underestimation would differ between the larger and the smaller project. This was seen as being a consequence of the number of items that require definition and estimation rather than being part of a deliberate or subconscious process of deception.

One of the respondents saw that this would of greater consequence in the bigger project than in the smaller project.

One of the EPCM respondents saw this as being a potential aspect but also saw that overestimation would be equally prevalent.
How can ‘cognisant’ cost overruns be mitigated?

There was a variety of responses received for this question. The intention of this question was to obtain comment on the process whereby known cost overruns can be mitigated.

Two of the respondents saw the necessity for thorough peer reviews during the period where the CBE is being generated. One of these saw the possibility of applying a process of cognisant weighting of the project in the tendering process. One respondent saw the necessity for not cutting the CBE to meet a financial model, or budgeting honestly and allowing sufficient time for this process. The scope being estimated should be understood fully and in sufficient detail to allow accurate costing.

Two of the respondents saw the process of applying a contingency to the project budgeting to allow for the scope gaps and the incomplete designs that are prevalent in the early design phase when the budgets are being assembled.

Two of the respondents saw the necessity for accurate cost controls during program execution. According to another there is benefit in early detection and the application of ongoing budgeting as new information becomes available.

Would you say that project returns are similarly biased?

All of the respondents saw that project returns are biased in favour of the project. One of the respondents saw this as a deliberate bias to sell the strong returns for the project. This stance was reflected by another respondent.

One of the responses saw that the ore body evaluations can be based on a ‘cut price’ reserve evaluation.

One of the responses stated that the returns would be based on a best case scenario; ideal pricing, ideal working costs, and ideal processing plant.

Would you say that project risks are misrepresented?

Most of the respondents saw that the risks inherent in the project could be downplayed or misrepresented during the processes leading up to the execution of the project. One of the respondents saw that this would be handed on to the execution team to manage.

One of the respondents saw the risk review process being a subjective process and thus subject to interpretation, hence subject to personal or group bias.

One of the respondents stated that in the risk review process peoples’ opinions and personal agendas come to the fore, for the EPCM Company the identification and mitigation of the risks is an essential aspect. Risk misrepresentation is therefore more likely to be an aspect of the client bias.
One of the respondents saw that experienced teams should be able to accurately identify most of the project risks.

The Client embedded EPCM was not aware of this process happening.

6.22 Forethought

**Do you have open team discussions during the CBE phase of the project?**

All of the respondents replied to this question in the affirmative.

In general, all of the participants were required to participate in the discussions during the CBE phase of the project.

One of the respondents said that these discussions did occur but not to the extent that there would have been a significant benefit to the CBE.

One of the respondents saw this as a knowledge and common understanding process for the project.

Another of the respondents saw this as an opportunity not fully taken advantage of as the client could do more to share information with the EPCM.

One of the respondents saw the necessity for the discussion to be chaired competently to ensure all participate equally, the meeting should not be dominated by one person or one group.

**Do you identify people who are ‘overinvested’ in the project?**

Some of the respondents did not fully understand this question.

Some of the respondents stated that often the persons who are ‘overinvested’ come from the client and are thus difficult to ‘contain’ and control.

The response from the Client embedded EPCM was in a similar vein where the persons ‘overinvested’ can be identified but are not controlled.

One of the respondents saw that this is a person that has to be managed in order to mitigate the risks of biases resulting from their opinions.

**How would you identify potential project failings at the earliest opportunity?**

Some of the respondents saw the necessity to carry out risk assessments, HAZOPS and constructability reviews. One of the respondents saw that this would be captured in the project risk analysis forums.

Some of the respondents highlighted the necessity for open, inclusive and honest communication in the project teams.
From the Client group response came the requirement for the desktop and scoping studies to identify the potential project failings.

One of the EPCM responses saw the benefit in comparing the project being developed with other similar projects and projects which were aborted and look for similarities. Also there was a requirement for applying suitable project controls and reviewing the information generated.

### 6.23 Project risk

**How do you define risk?**

The responses to this question were very similar:

- The uncertainty of achieving the desired outcome, the probability of a negative occurrence.
- Uncertainty of outcome and the impact of this event.
- Anything that can cause harm to the project.
- The chance that an event could occur that could lead to injury, damage or loss.
- The potential for an event that could have a detrimental time or cost impact.
- Something that does not go according to plan and has a negative impact on the project.

**What would be the basic principle of risk management?**

Most of the respondents had the same approach to risk management:

- Identify the risk
- Determine the impact of the risk
- Determine the probability of the risk occurring
- Develop a strategy to mitigate the risk
- Measure the effectiveness of the mitigation

From the Client group came the response adding the identification, analysis and response to risk factors throughout the life of the project. Increasing the effect of positive events and reducing the effect of negative events.

Risk management according to some respondents also required the regular review of the project risks and the monitoring of the effectiveness of the risk treatment plan.

**What do you see as being the principle risks on your project?**

There were similarities in the responses from the different projects. The risks were either project based or EPCM based:

- Significant changes in scope coming from the client, a significant effect on the execution strategy introduce rework and delays
- Underperformance of the main contractor, having a significant effect on the project schedule performance
- Loosing skills from the EPCM base
- The performance of the plant not meeting the planned performance
- Client cash flow constraints
- Client management style and relationship with the EPCM
- The inherent risks associated with mining projects such as safety

What is the best time to address project risks?

Most of the responses stated that the risks should be addressed as soon as they have been identified and quantified.

As soon as a risk is identified the risk should be quantified and action taken to mitigate the risk as appropriate.

Some of the respondents identified this process as being continuous process for the life of the project.

What would you see as being the two principle sources of risk?

There was as expected a variety of generic responses to this question these are tabulated below:

- People - 3 responses
- Environment - 2 responses
- Client - 2 responses
- Internal – 1 response
- External – 1 response
- Human behaviour – 1 response
- EPCM – 1 response

And there was as expected a variety of specific responses to this question these are tabulated below:

- Project team knowledge
- Stored energy
- Paper
- Capital
- Poor planning
- Not delivering on promises

Some of the responses as above are specific and not the generic classifications that were being requested.
In the team gathering process what would say are the challenges?

Most of the responses were looking at identifying the resources that would be in demand, required for the project execution:

- Identifying the correct resources for the project scope; skills, knowledge and experience
- Identifying the correct number of resources and the right mix or resources
- Having these resources required at the right time
- Getting the people to work together

One of the responses from the ECPM group identified the problems with getting the resources released from commitments and with people trying to work on two projects concurrently.

One of the responses from the Client group, obviously with a smaller labour pool identified challenges in people not willing to participate and not understanding the risks associated with the project.

What would be the principle human risks?

Some of the responses received reflected the responses for the previous question.

Some of the responses received discussed human behaviour and getting the project teams to work together, compatible teams.

The response from the Client group discusses the impact of human behaviour on the project execution.

This was echoed in a response from the ECPM group that highlighted human nature and all that that can bring to the project execution team.

Another response from the EPCM group lamented a regular impact on a project in the loss of a critical resource at a critical time.

How should knowledge gaps be addressed?

Many of the responses reflected on providing training and developing mentoring activities in the project team to close the knowledge gaps. In addition to this the responses discussed the necessity to spend the time creating the correct project team with the correct mix of skills and experienced team members.

Should a knowledge gap in the team occur then the response was to identify this as soon as possible and either from inside the company or with selected resources, subject matter experts, from outside the company fill the gaps. This could be on a temporary basis.

According to some responses the gaps could be filled with additional resources.
The response from the Client group took the practical approach of conducting additional test work and studies to bridge the knowledge gap, searching the knowledge database and consulting experts in the field.

**What would you describe as being operational risks?**

Most of the responses reflected on the day to day operational risks incurred during project execution. Examples cited included losing a skilled team member or a vital component not being available when required.

Two responses discussed the project execution team being able to complete the tasks at hand to the required standard and in the correct time frame.

The response from the Client group reflected on the actual losses differing from the expected losses. The actual losses are affected by the systems, people and processes applied in the operational environment.

**Do you evaluate business risks as well as operational risks?**

All of the responses received were in affirmative.

In the EPCM environment, according to the responses there are two risk evaluations; the client to EPCM environment risk assessment and the project based risk assessment. Only the operational risk assessments are shared with the Client.

The Client embedded EPCM group reflected on the zealous Client risk assessments and risk evaluations that cover such items as money, time, reputation, legal and safety.

The operational risks according to the Client embedded EPCM are covered by the base line risk assessments.

**In the risk analysis process are internal and external risks contemplated?**

Four of the responses were in the affirmative and offered no further information or discussion.

From the Client embedded EPCM there was an example cited where labour issues are identified and tracked, contingency plans are made to reduce the business impact.

Other EPCM group responses reflected on the necessity to carry out a holistic risk management:

- Client,
- EPCM and,
- Contractor.

Another EPCM group response stated that within the EPCM only internal risks are evaluated and in the Client project risk assessments internal and external risks are evaluated.
What are the basic steps you follow in the risk analysis process?

In the project environment, as was obvious from the responses received this is a well-managed and practiced process.

- Identify all of the possible project risks
- Assess the risk
- Ranking of the risks to identify those to be addressed
- Evaluation of the risks to identify the most suitable point in the execution to address and mitigate the risk.
- Develop a contingency plan
- Review the progress and effect of the risk mitigation technique that has been applied, re-rate the risk after mitigation

The risk analysis must be regular and respond to new activities and changes in the execution teams.

Can you be certain that all risks are identified in the initial risk management processes?

All of the responses were in the negative, risks sometimes go un-identified and risk evaluations have to be regular and even continuous.

From one of the EPCM group it was noted that the risks identified in the risk assessment process are only the risks that are apparent to the risk assessment team.

From the EPCM group came the response that some new risks might arise during the execution process. The EPCM group also identified the need to refine the risk assessment as designs are refined and more information becomes available.

What would you say are your project's five principle risks?

As would be expected there was a variety in the responses received for this question. These are tabulated below:

EPCM issues

- Main contractor performance - 4 responses
- Design oversight - 3 responses
- Program - 2 responses
- Procurement - 2 responses
- Safety incident – fatality with legal accountability - 2 responses
• Designs late due to continuous changes – 1 response
• On time completion of the study or studies – 1 response
• Change notices delayed – 1 response
• Principle technology does not work (Client group) – 1 response
• Principle technology is not reliable (Client group) – 1 response
• Staff retention – 1 response

Client issues:
• Capital availability - 3 responses
• Significant changes in scope from client - 2 responses
• Client general concerns – 1 response
• Client takes over part of the scope – 1 response
• EPCM contract is retendered and awarded to another contractor – 1 response

Project environment:
• Commodity price slump – 1 response
• Economic downturn – 1 response

External environment:
• Licensing - 2 responses
• Environmental, social, heritage site – 1 response
• Eskom power availability and reliability – 1 response
• Legislative compliance – 1 response

What are the sources of these risks?

There was general consensus regarding the source of these risks:
• Client - 6 responses
• Contractor - 5 responses
• External environment, commodity prices - 3 responses
• EPCM Company - 2 responses
• Community – 1 response
• Industrial action – 1 response
• Material costs – 1 response
• Technology used for the first time – 1 response

Who is the best party to manage or take ownership of these risks?

There was a variety of responses for the person to take ownership varying from:
• Executive Director
• Client
• Project Manager
• Engineering Manager
• Construction Manager
• The Project Team as a whole

Contained in the responses was the persons responsible for mitigation – this according to two respondents was each person being responsible for their own risks.

**What role does communication play in the risks management process?**

There was consensus amongst the respondents that communication is the key to effective risk management in the project environment.

Everyone must know what the risks in the project are and the risk must be kept front of mind. New risk identification is the responsibility of everyone involved in the project.

According to one respondent people need to be informed of the risks and the mitigation techniques need to be communicated for people to be able to act on them.

**In project execution what would be the principle risks facing the large scale project?**

In the responses received there was a general trend the key points are tabulated below:

- Capital availability – 5 responses
- Cost overruns – 3 responses
- Schedule overruns – 2 responses
- Scope changes – 2 responses
- Resources – adequate and sufficient – 2 responses
- Contractor performance – 2 responses
- Scheduling conflicts – 1 response
- Procurement – 1 response
- Stakeholder management – 1 response
- Quality control – 1 response
- Legislative compliance – 1 response
- Permitting – 1 response
- Safety – 1 response

**Are the conventional risk management processes appropriate for large scale projects?**
There was a diversity of responses to this question; some said yes and some said no. Some said yes that the risk process was adequate but would have to be modified:

- The risk management process is adequate but would have to be continuous and as thorough for the duration of the project.
- The complexity and duration of the LMM project presents a complexity of scale to the risk management process.
- The risk management process needs to be streamlined so that the risk management process can be followed more frequently during the execution of the project.
- Would have to be scaled up and more widely distributed. (Client embedded EPCM)

For large scale projects would it be more appropriate to be proactive as opposed to being reactive?

Three of the responses from the EPCM group were a combination, being proactive to allow for planning of the responses to the risks. The other aspect highlighted was to be able to respond to risks as they become apparent. According to one there was a place for a reactive approach to risk management particularly in a fast moving environment.

Two of the EPCM group responses were emphatic that the proactive approach would be more appropriate with the identification of the problem areas up front. This allows for the preparation of project contingency plans.

What new risks are introduced by managing a portfolio of projects?

Some of the EPCM response saw the additional complexity introduced by managing a portfolio of projects. According to one this would introduce time and priority management and challenges and being exposed to multiple liabilities.

Risks could be commuted between projects.

The Client embedded EPCM saw that there could be a reduced focus possibly causing some of the detail to be missed and emerging risk not to be picked up in good time.

Some of the respondents saw the benefits of running a portfolio of projects with understanding of risks on one project giving insight on another.

Is the current risk management process suited to managing the portfolio of projects?

Most of the responses indicated that the risk management processes were suited to managing a portfolio of projects.
Five of the responses were emphatic yes votes for the current processes. One of the yes responses stated that it was suitable, and the company would have to focus on the highest rated risks and key a watching brief on the rest. The processes would have to be scaled up to manage the portfolio.

One of the responses highlighted the need to carry out a risk assessment for the project manager to highlight the risks associated with the multiple project environments. Another of the responses stated that the current risk management process was not suited to the multiple project environments and the risk integration required.

The response from the Client group was an emphatic no.

**What would you describe as being intuitive risk management?**

All of the responses received for this question saw the following as an intuitive risk management process. This would be based on the experience of the project team, the application of heuristics, gut feel, risk management through natural caution, intuition, project team caution, using previous experience and lessons learnt.

From many of the responses this is an approach to risk management that can be applied and then followed up with a conventional quantitative process. This approach will often be applied in a risk assessment process but a caution from one response was to avoid channelling the risk management process.

**What new risks can sub-contractors introduce?**

Most of the responses saw the increased commercial complexity introduced to the project.

In addition to this was the additional communication channel, the additional group not familiar with the site specific risks and the project history.

One of the respondents saw the contractor specific risks of knowledge, competence, management, skill, values and culture.

The respondents failed to identify the relational risks within the project and outside the project.

**Are all risks manageable?**

There were five ‘yes’ responses and three ‘no’ responses.

In the yes field; the risks have to be known and if they are known they can be managed and mitigated, some of the risks would require no action. The effectiveness of mitigating action would have to be monitored.
In the no field was the comment that some of the risks can be lived with and some cannot be influenced by any action. These risks would be monitored for movement from the previously rated impact.

Are all risks managed?

There was an even split between the ‘yes’ responses and the ‘no’ responses to this question.

The ‘yes’ responses to this question:

- All risks that have been identified have by definition been managed,
- All known risks are managed,
- Some risks may not require any mitigation, and some may be too expensive to manage.

The ‘no’ responses to the question:

- We only manage the higher rated risks,
- Some risks may be documented but not managed.

Are all risks declared at the inception of the project?

All of the responses received were negative:

- Some would only be picked up by a different team,
- Some would only be tackled in the execution of the project,
- Only the high level risks would be known at the inception,
- Risk management is an ongoing effort that depends on the context at the time.

How would your categorise risks?

As would be expected there was a variety of responses to this question these are tabulated below:

- Area - 4 responses
- Perceived occurrence - 3 responses
- Scale of effect - 3 responses
- Cost of risk event - 2 responses
- Custodian - 2 responses
- WBS – 1 response
- Cost to mitigate – 1 response
- Function – 1 response

One of the respondents did not understand this question.
Are some risks ignored?

Of the responses received four were ‘yes’.

One of the responses stated that all of the risks identified will be monitored by the project team, all will be evaluated, and some will not require any mitigation effort.

Some of the risks can be parked and re-evaluated periodically to see if the circumstances affecting the risk have not changed.

Risks according to one are treated, terminated or tolerated.

Why could some risks be ignored?

There was a variety of responses to this question.

- Some risks can be side-lined, low risk and or low cost of impact,
- Because there is nothing that could be done to mitigate this risk,
- The risk is low and can be tolerated,
- There is no impact and very low possibility,
- Mitigations fall outside the specific project period,
- Risks are not ignored, once there is no probability of occurrence then the risk can be retired.

Are you aware of all the risks present in your project?

There was a variety of responses to this question.

Some responded that they are aware of all of the risks that have been identified but not all of the project risks have been identified.

Some were aware of all of the risks in their area, aware of the top ten risks, but not aware of all of the risks present in the project.

Some responded saying that some of the new risks will only be identified during the execution in the project.

There are obviously some risks that have not been identified and some which will occur only as the project moves into a different phase in the execution process.

Is all risk evaluation and risk management satisfactory?

Some of the responses were in the positive and some were in the negative.

Some of the responses were happy with the risk evaluation process but stated that if the mitigation proved ineffective then this could be revised.
The risks raised are a result of the collective experience of the evaluating group, the risk review process can be cursory, and the mitigation techniques can be ineffective.

One of the responses stated that there is always room for improvement and often the processes are rushed, it is important to update this review regularly.

One of the responses stated that there is more that can be done to display the risks and track the risk mitigation.

The risk evaluation process is always subjective and there is little opportunity to ensure there is calibration between the risk evaluating teams.

- Does your client apply an early design commitment strategy?
- Why is this applied?
- Is it successful?
- What about late changes to the project definition?

There was either an early design commitment strategy or there was not.

One of the respondents stated that in a shaft sinking project there has to be an early commitment to certain critical aspects. Some aspects can be changed but there has to be a sound business case for this.

One of the respondents stated that there is a strategy to channel the client to an early design commitment. This assures that the drawing office and design offices are utilised effectively. The client has to buy into this process and late changes are controlled.

Another respondent stated that the operational personnel like to keep options open. The client project personnel like to have an early design commitment so that the costs can be understood, this come with the risk of late changes and EPCM rework.

A respondent stated that there will always be an element of change in the execution of a mining project.

A respondent stated that there is a process for an early design commitment to allow for an element of float in the project, this was successful and changes are managed through the change management process.

Yet another client opted for an early design commitment but this had failed and additional trade off studies are being asked for.

Do you practice design postponement to as late as possible to minimise risk?

There was a wide variety of responses to this question.
Some agreed that this would be the ideal situation as the design would be as late as possible and the design input information would be as clear and accurate as it could be. One of the down side risks would be that should the project completion be brought forward then there would be challenges for the design engineering and the drawing office.

One of the respondents reflected on the challenges of the mining project where designs are required up front to size excavations.

One of the responses reflected on the up side to design postponement in minimising the amount of rework as all of the input information would be known.

Some of the responses reflected the schedule requirements and some of the project were under too much pressure to be able to delay packages.

The Client embedded EPCM would wait for certified vendor drawings before commencing with design work, this would minimise rework later.

### What factors affect the client’s decision to expedite the design process?

There was a variety of reasons tendered by the answers to this question.

Most of the answers centred on the impression that there would be a cost saving by expediting the design and drafting processes, there would be an improved return on the investment, the client can become more involved in the design processes, the schedule can be fast-tracked, some of the risk can be mitigated by creating program float and some of the follow on design items can be started. There is also a benefit in that some of the plant can be purchased early to take advantage of better market prices.

Some of the down side issues were noted in that there could be rework should some of the design fundamentals change during execution.

### To what extent is concurrent engineering practiced?

The responses received indicate that this is a common practise where the EPCM budget can tolerate this and the program expediency is proven to be necessary. The comments received are detailed below:

- The concurrency has to be practical,
- Where the design information is available and complete,
- When the time frame requires this,
- When the resources are available,
- When two teams are required to work in the same area.
These responses indicate that the budget has to be available, the resources have to be available, and the project program has to dictate that this is required, the information has to be available and complete, and the risk of rework has to be minimal.

What risks are induced by the EPCM Company and Client processes?

The response from the Client group indicated the primary conflict from the client perspective; the EPCM Company wants the project to proceed in order to be able to bill hours and earn revenue whereas the client wants to grow and or improve the business. These objectives can be in conflict.

An EPCM group response indicated the following points of conflict:

- Communication,
- Goals and direction,
- Differences in opinion,
- Differences in strategy,
- Understanding.

These were reflected in some of the responses including the response from the Client group.

Several of the responses reflected that where the Client and EPCM processes are not aligned then there could be a difference in priorities and technical solutions.

What are the project specific challenges relating to ‘concurrent engineering’?

Most of the responses reflected on the risk of cost and time overruns resulting from rework.

Some of the aspects that are being worked on currently may not be reusable should one of the items have to be re-specified. One of the examples cited was the resizing of a pump; this could result in the redesign of all aspects relating to the pump sizing.

Another response received highlighted the need for a clear unambiguous understanding of, and agreement on all the design input data.

Two responses received from the EPCM group highlighted the need for sufficient and adequate resource to tackle the concurrent activities. It was also noted that the engineering resource utilisation would peak and therefore may compromise the continuity of the resources for the duration of the project.

Another response from the Client embedded EPCM looked at the coordination challenges presented by two engineering teams working concurrently; different systems, different software and different understanding of the design concepts.

What would you say are the risks introduced by globalisation?
There was a general agreement between the responses received:

- Coordination,
- Developing a common understanding of the project deliverable,
- Communication and language,
- Cultural differences,
- Global assumptions used to evaluate projects may not be valid.

One of the more complete responses highlighted, apart from the above the; procurement standards, legislation, taxation, time frames and bribery.

There are of course two aspects to globalisation the global EPCM and the global Client. The response from the senior member from the EPCM group stated that there should be no challenges presented by globalisation as all of the issues should have been considered before the initiative is undertaken.

**Have you considered using a risk breakdown structure?**

By far the greatest numbers of responses received were in the negative, six out of eight. Most of the responses received stated that the systems in place were satisfactory, the risks are clear and understood. The risks are identified and rated using specific criteria and that actions are based on resolving the highest rated risks.

One of the responses stated that should a more complex project be undertaken and the risks become more challenging to manage then a RBS system could be considered.

There is a possibility, considering previous responses to risk analysis questions that the risk systems are too onerous and a RBS system could result in more risks being identified.

**Are the risks on your project affecting the business clearly understood by all on the project**

There was general consensus that the project risks affecting the business were not understood by all participants.

There was a comment by one of the EPCM group that the discipline groups understood the risks, intimating that there was not a general requirement that all of the risks are understood by all. Some of the risks not identified by the team would not be required to be disseminated.

What was being intimated by some of the responses was that risks should only be disseminated to the level where corrective/ remedial action can be implemented.
### 6.24 Project sponsorship

**What would you say is the role of the project sponsor?**

Most of the responses were in agreement on the role of the project sponsor:

- The executive with the interest of the success project execution at heart, to understand the necessity of the project,
- The persons to select the project manager for the project,
- High level link between the project team and the client senior management/stakeholders,
- To ensure the project remains on track,
- The persons that has identified the need for change in the organisation and who is committed to ensuring the change happens, project champion,
- An experienced resource to the project at the highest level,
- To provide support to the project manager from the board level,
- When required to provide insight to the project team,
- Approves the project budget.

The project sponsor remains in the background and at the high level in the structures.

**What would you say are the beneficial attributes of a project sponsor?**

There was a general consensus amongst the EPCM responses and these are tabulated below:

- Communication skills - 4 responses
- Seniority in the company, authority - 3 responses
- Manage the company interfaces, know the organisation - 2 responses
- Good networks - 2 responses
- Leadership - 2 responses
- Big picture view of the project - 2 responses
- Experience in the type of project - 2 responses
- Honesty and integrity - 1 response
- Project experience - 1 response
- Proactive - 1 response
- Objective - 1 response

The responses ranged from company skills and seniority, external networking, personal skills and a range of project skills.

The response from the Client group was thus; a good project sponsor can make a mediocre project fantastic and the poor project sponsor can delay and frustrate a fantastic project team.
How does this role differ between the Client sponsor and the EPCM Company sponsor?

Two of the responses identified the following:

- The Client sponsor looks after the needs of the Client,
- The EPCM sponsor looks after the needs of the EPCM.

One of the responses from the EPCM group identified the need for the EPCM project sponsor to have an overview of many projects in the EPCM environment and to prioritise to allocation of resources to the projects.

The responses from the Client group identified the conflict between the EPCM and the Client; the EPCM project sponsor wants the project to proceed so that the EPCM can bill for hours whilst the Client project sponsor is focussed on the business growth and improvement. According to the Client group response the Client project sponsor is often the person who has identified the need for the project and would therefore have a vested interest in the project outcome.

The Client project sponsor would be the owner of the project funding.

One of the responses from the EPCM group gave insight into the practical aspect in so far as the Client project sponsor is more involved in the day to day aspects of the project whilst the EPCM project sponsor is more stand-off.

What would you say are the key behaviours of the project sponsor?

There was general agreement regarding the key behaviours of the project sponsor and these are tabulated below:

**Executive level:**

- Manage the client interface looking out for developing opportunities - 3 responses
- Follow the project progress – time, budget and scope - 3 responses
- Championing the project at executive level to secure support - 2 responses
- Providing feedback on status reports and ensuring the key stakeholders are informed - 1 response

**Management level:**

- High level guidance to the project manager and engineering manager - 3 responses
- Hold the project manager accountable - 1 response

**Project level:**

- Keep the project in context - 3 responses
- Big picture view of the project - 1 response
- Clear direction for the project - 1 response
• Project resourcing - 1 responses

Personal attributes:
• Positive and motivational - 3 responses
• Objective and unbiased - 1 response

From the above there was a clear need for activities at an executive level for the project to ensure the project is understood and supported at this level. The project sponsor would also act as an advisor to the project management team and to have a controlled input in to the project level.

What would you say would be successful outcomes for the project sponsor?

The response from the Client group was simply that the project delivers the original outcomes as envisaged.

The EPCM group responses are as tabulated below:

Client:
• Client satisfaction during execution and on project completion - 5 responses
• Minimal client conflict - 1 response
• Enhanced client relationship, future business - 1 response
• Successful integration of the client and EPCM team - 1 response

EPCM:
• EPCM business needs satisfied; learning, reputation, profit margins - 3 responses
• No EPCM inefficiencies affecting the project - 1 response
• Successful project team - 1 response

Project:
• Project completed on time, on budget and to specification - 4 responses

Clearly from the above there are there areas of primary importance; the client, the EPCM and the project. The primary successful outcomes are client satisfaction obviously driven by a successful project outcome in all aspects and the EPCM requirements for increased learning, enhanced reputation and the necessity to achieve profit margins.

What would you say would be detrimental sponsor behaviours?

There was general consensus amongst the EPCM group responses these are tabulated below:

• Micromanaging, overinvolved in the project, overbearing - 5 responses
• Unavailable, not assisting the project manager - 3 responses
• Lack of leadership, taking sides - 2 responses
• Authoritative, not listening but telling - 2 responses
- Out of touch with the project - 1 response
- Not interacting with the client and stakeholders - 1 response
- Talking down to people - 1 response
- Neglecting the project, overcommitted - 1 response

Clearly from the above the key detrimental behaviour would be the project sponsor becoming overinvolved in the project execution. This would disempower the project team and the project manager. The second ranked detrimental behaviour was becoming unavailable to the project and the project manager. The project sponsor has to be effective yet not over invested in the project. The primary risk for the project sponsor is to become over committed to other aspects of the business and to be unavailable to the project or projects in execution.

How should the project sponsor behave during the execution of the project?

There were two principle requirements from the sponsor as indicated in the responses received. The sponsor must be in contact with the project and the project manager and the sponsor must be in contact with the client to assure the project is being executed to the client satisfaction.

Responses indicated that the project team must be allowed to execute the project and be given the latitude to establish a working and beneficial relationship with the client.

The project sponsor, according to responses, must be up to date with the project execution and be familiar with the execution difficulties. The project sponsor must be able to choose the optimum time to become involved in the project to resolve differences between the client and the project execution team.

From one respondent there was a need for the sponsor to ensure the EPCM company requirements are maintained.

The response from the Client group stated adamantly that the project sponsor has to be in the background during project execution, the project sponsor that gets too involved in the day to day execution of the project has disempowered the project manager. The project sponsor has to create the environment for project success.

What would you say are the principle project sponsor failings?

There was a variety of responses to this question these are tabulated below:

Client interaction:
- Lack of high level interaction with client senior management - 2 responses
- Being too client orientated - 1 response

EPCM function:
• Being involved in too many projects - 3 responses
• Not see the risks in terms of EPCM performance - 1 response

Project function:
• Becoming over involved in the project - 3 responses
• Not understanding the project complexities - 1 response
• Falling behind in the progress on the project - 1 response
• Lack of strategic involvement in the project - 1 response

The principle failings identified was a lack of interaction with the client, being spread too thin over too many projects and becoming overinvolved in the project. There is an optimal level of involvement and being overtasked by the parent company.

The response from the Client group saw the principle project sponsor failings as being too busy with their main tasks, being too involved in the project and being over prescriptive to the project manager.

How would you overcome inadequate project sponsorship?

There was a variety of responses to this question.

In some of the cases there was a trend to bypass the project sponsor and deal directly with the senior management of the client company and the EPCM Company. This was contained in two of the responses.

One of the respondents from the EPCM group would escalate the issue to more senior management in the company. Another two would engage directly with the project sponsor or escalate this to more senior management.

One of the respondents would initiate contact with the project sponsor, schedule a meeting program and copy reports to the sponsor.

The response from the client group examined a need for an agreement between the project manager and the project sponsor. The agreement would be regarding the amount of time that would be allocated to the project, the reporting content and frequency, a meeting schedule the nature of the issues that will be escalated to the project sponsor.

What would you say are the challenges facing the project sponsor in the EPCM Company environment?

The responses received were similar in the identification the challenges facing the project sponsor these are tabulated below:

Project challenges:
• Being engaged in multiple projects with conflict of interest, changing priorities - 4 responses
• High levels of complexity and multiple clients - 2 responses
• Volatile projects – 1 response
• Providing a positive influence on the project – 1 response
• Being removed from the project but still being aware of the project in execution – 1 response

EPCM challenges:
• Being over tasked with other responsibilities in the EPCM Company - 3 responses
• Not being recognised as a valuable resource to the project – 1 response

Client challenges:
• Being able to engage with the client sponsor – 1 response

Most of the responses saw the challenges in project involvement and managing multiple projects. The EPCM challenges saw being allocated to many different projects and being seen as a valuable resource to the project.

The response from the Client group highlighted the need for a balance between being involved and yet relying on the project team for execution. The project sponsor must champion the company’s vision, goals and expectations for the project without micro-managing the project.

6.25 Communication

What are the fundamental drivers of project communication?

There was a variety of responses to this question from the interviews.

One response stated that the communication is to inform and involve personnel in the project; this can be to the EPCM group, the Client group and to the whole EPCM Company.

One response from the EPCM group reflected on a fundamental being about getting people working efficiently on their deliverables. Another response reviewed the nature of the communication; reporting and planning, gives direction and reports on tasks, reports deficiencies and gives notice.

The response from the Client group reflected in the need to listen and that communication and leadership are integral. Communication is about understanding the project challenges, the real team issues and understanding the issues of the project sponsor who is ultimately the owner of the project. The Client group response also stated that communication is about being present, visible and engaged with everyone on the project.

A response from the EPCM group stated that the fundamental drivers of communication were to cover everyone on the project, to determine the frequency of communication and the medium to
be used. Communication was to align everyone, inform on the relevant issues and to identify problems areas. Communication should be without fear of retribution.

**How did you establish your communication strategy?**

There was a variety of responses to this question, these are tabulated below:

- Identify the personnel involved, stakeholders - 3 responses
- Identify the frequency of the communication - 3 responses
- Identify the items and content to be communicated - 2 responses
- Identify the form of the communication - 2 responses
- Identify the key meetings and the frequency of these meetings - 2 responses

The communication strategy should be established at the start of the project.

Other responses from the EPCM group based their communication strategy on other project successes and allowed the strategy to evolve over the development of the project.

**What are the negative effects of poor communication?**

The responses received indicated that there would be chaos in the project. Poor information would result in misunderstandings, there would be levels of irritation, reduced commitment and the project scheduling would be poor. There would be confusion, delays in project execution, and there would be an element of irritation with the stakeholders.

There is a possibility that changes are not incorporated in the design.

One of the responses from the EPCM group stated that the project would stay in the storming process.

For the project team there could, according to the Client group response, lower efficiency, reduced team morale, decreased propensity for innovation and conflict.

The response from the Client embedded EPCM group examined the necessity for good communication between the engineering disciplines and the necessity for good communication between engineering and procurement.

**Is all communication on your project formal?**

All of the responses agreed that there was informal communication on the project and most attested to the value of informal communication in the project environment.

According to the Client embedded EPCM there is a great deal of informal communication, the medium of the informal communication would have to be reviewed.
One of the responses indicated that there was a great deal of informal communication on the project but all had to understand the boundaries of the informal communication. It has to be understood by the project team that certain communication has to be channelled through the formal channels of the project.

Communication with the client often has to follow the formal communication channels.

**What is the value of informal communication?**

All of the responses attested to the value of the informal communication present in the project. There is a greater willingness to share information and express concerns in the informal communication. Informal communication allows for brainstorming, constructive argument and problem solving.

According to one response it will be necessary to follow up some informal communication with a formal report should this affect the project deliverable.

Informal communication can apply heuristics to problem solving improving the project delivery to the client’s benefit.

According to the Client embedded EPCM informal communication can build relationships and trust, the task issues can be resolved quickly.

**Who is responsible for the communication on the project?**

Generally, the responses stated that everyone on the project is responsible for communication. Some of the responses reflected on the responsibilities of the PSO, Project Liaison Officer, Document Controller, and the Contracts Manager.

The Project Manager according to some has ultimate responsibility for the project communication and the formal project communication.

One of the EPCM responses reflected on the problems associated with people on the project not communicating.

**What is the root cause of the proliferation of asymmetric information?**

There was a variety of responses to this question depending on the individuals understanding of the term ‘asymmetric information’.

The response from the Client embedded EPCM was of a lack of understanding of the term asymmetric information.
Responses from the EPCM group indicated that this was the provision of only the information that supports the sender’s opinion. Asymmetric information is often easier to accept as it supports and promotes the project in execution.

A response from the EPCM group stated that asymmetric information has to be managed as it can ultimately be detrimental to the project outcomes.

Another two EPCM responses regarded information asymmetry as being team members not being willing to part with information as this would risk their future value to the project. Others saw this as misinformed persons or differences in opinion between the client and the EPCM.

What is your interpretation of asymmetric information?

Most of the responses had a fair interpretation of asymmetric information:

- One person knows more than the other - 3 responses
- Information is distorted or incorrect - 2 responses
- Contrary information is suppressed or withheld - 1 response
- Information is disseminated selectively by the group that has to the group that needs - 1 response
- Information that is misinterpreted or misunderstood - 1 response

Again the response from the Client embedded EPCM was of a lack of understanding of the term asymmetric information.

The full effect of asymmetric information on the project outcomes or the project value was not fully conveyed in these responses.

What are the possible effects of asymmetric information?

If the principle of asymmetric information is understood, then the effects are understood:

- Decision are made on faulty or skewed information - 3 responses
- Put pressure on the execution team to achieve unrealistic targets - 1 response
- Poor project progress against biased schedules - 1 response
- The project struggles to achieve objectives, negative outcomes - 2 responses

Other effects included; misinformation, incorrect team focus, communication breakdown, execution delays, rework and an increased perception of risk.

In general, it was understood by all the respondents that the asymmetry of information was detrimental to the project on many levels.

How can asymmetric information be compensated for?
There was a variety of responses to this question that have been tabulated below:

- Reviews of critical project decisions - 3 responses
- Applying balance to the project information - 2 responses
- Peer reviews of the project that are objective - 2 responses
- Getting all the parties around a table, informal communication - 2 responses
- Factual reporting of issues - 1 response
- Well designed and managed communication strategy - 1 response
- Identifying asymmetric information and highlighting such - 1 response
- Applying learning and knowledge database information - 1 response

There appears to be a strong requirement for reviews of critical project information and identifying the skewed data so that a balance can be applied.

One of the measures not identified was the identification of the sources of asymmetric information; this would possibly be because this is often from the client. These sources are often required for their inputs so the information is accepted but balance provided through the reviews.

What are the advantages of a competent communication system?

There was general agreement on this topic:

- Everyone knows what is happening, aware of the project deliverables, know expectations - 5 responses
- People can make informed and good decisions - 3 responses
- Efficiency, accurate information circulated - 2 response
- Things get done on time, reduced delays - 2 responses
- Increased trust, reduced frustration - 2 responses
- Successful project communication, understanding - 2 responses
- Increased information sharing - 1 response
- Reduced rework - 1 response
- High quality engineering outputs - 1 response
- Clear project dashboard - 1 response
- Reports are peer reviewed - 1 response

The responses reflected the dissemination of accurate information keeps all the project team members informed as to the status of the project. This facilitates the making of good decisions and this has a positive effect on the project regarding the meeting of critical dates.

The communication system ensures the reporting is accurate as it is peer reviewed and distributed in good time. The increased accuracy of the information creates trust in the project information and reduces frustration.
What are the challenges confronting effective communication?

The responses reflected on the following issues. The stakeholder group can change and this can go unnoticed. The information circulated has to be unambiguous and concise; this is where the peer review is essential as the tendency is to be verbose in communication.

In the mining industry stakeholders have to be informed in the correct sequence, the informal communication is often quicker than the formal communication so there is a risk of inaccurate information being circulated.

There is a risk that electronic communication can be circulated beyond the intended group. With electronic communication being easy to distribute there is a risk of communication being ignored and the concurrent information overload. Project time constraints require fast and effective communication.

The EPCM exists in a global environment and the teams become globalised this requires constant communication irrespective of time zones.

How can communication be used to manage the client perceptions?

There was general consensus amongst the respondents to this question.

Communication has the ability to create an alignment between the client and the EPCM Company through common understanding. Client concerns have to be addressed in good time.

The communication has to be clear and concise.

Accurate and timely communication enables good decisions to be made in a supportive environment.

The communication has to be honest and open; disagreements within the delivery team have to be resolved prior to a presentation to the client.

6.26 Project close-out

In the execution of the project are life-cycle costs considered?

There was general agreement that the life-cycle costs are considered in the execution of the project. This is to ensure the project deliverables meet the client’s requirements, particularly with regard to the energy usage and time of energy usage.

One of the comments received from the EPCM group was that mining projects are reasonable straightforward from an engineering point of view and have clear guidelines. It is however good engineering practise to design and select the plant with lifecycle costs in mind.
One of the EPCM responses indicated that the life-cycle costs would be brought into the final phase of the design, this would be once the plant and the plant performance requirements have been considered.

**What post project completion changes have been executed on your project?**

Some of the projects included in this study have not reached the completion and handover phase of the project so there have been no post project completion changes.

One of the responses indicated that the client took over the installations prior to the installation being handed over. The example cited was a mud handling system and a conveyor installation.

**What are the root causes of post project changes?**

As could be expected there was a variety of responses to this question:

**Client originating causes:**
- Fundamental changes in thinking in the client camp, changes in the project design criteria - 3 responses
- Budget constraints not allowing the full scope to be completed - 1 response

**EPCM originating causes:**
- Not discussing and agreeing the project deliverables with the client operational personnel, scope not being agreed and understood up front - 5 responses
- Not involving the client in the conceptual layouts - 2 responses
- Unproven technology, equipment not functioning to the specification - 2 responses
- Not meeting the performance criteria - 1 response
- Poor planning - 1 response
- Defects in the work completed - 1 response

There was a split between aspects reflecting the Client performance and aspects reflecting the EPCM performance.

**What post project changes are taking place?**

As before there were some of the projects where no post project completion changes are taking place.

The responses received indicated a variety of responses:
- Requirements for increased production,
- Changes in the mining methods requiring an increase in staff required for the shaft,
- Requirements for increased efficiency in ore handling,
• Increased hoisting capacity,
• Changes to the mud handling philosophy,
• De-bottlenecking processes,
• Increased requirements for monitoring activities underground.

From the above there is a distinct requirement for increasing the production from the shaft. There would be an opportunity for building the additional capacity at the start of the project in the inception phase.

What are the effects of changes in a project?

There was a general agreement amongst the respondents and these are tabulated below:

- Additional time - 5 responses
- Additional money, capital - 5 responses
- Lower quality of installation as the changes are not fully incorporated in the original design, cluttering of the real estate - 2 responses
- Delays in the project start-up - 2 responses
- Client has to agree to the changes, give an instruction - 2 responses
- EPCM reputational damage - 1 response
- Demoralised team - 1 response
- Urgent management application - 1 response
- A full design review would be required - 1 response

The two most significant responses were the additional time required for the late modifications and the requirement for additional capital. There would of course be a delay in the completion of the project and hence the loss of revenue for the client. The additional costs could include some of the plant having to be replaced therefore wasted capital.

What are the main causes of post project changes?

There was a general consensus amongst the respondents and these are tabulated below:

Design aspects:

- Changes in the client requirements for the project, extensions to Life of Mine - 4 responses
- Unknown or untested technology, using the technology close to the limit - 2 responses
- Unclear design criteria - 2 responses
- Poor original design - 1 response
- Additional functionality required by the client - 1 response
- Poorly defined deliverables - 1 response

Capital aspects:
• Capital constraints - 1 response
• Inadequate budget - 1 response

Project management aspects:
• Poor planning - 2 response
• Poor quality workmanship - 2 responses
• Lack of client involvement from the start of the project - 1 response
• Poor change control - 1 response
• Changes in the client team - 1 response

What can be done to reduce or mitigate post project completion changes?
The responses tendered by the respondents are tabulated below:

Design aspects:
• Involving the Client (projects and operations) in the conceptual and design aspects, getting sign off of accepted concepts – 4 responses
• Obtaining a clear and unambiguous design brief project scope from the client - 4 responses
• Carry out internal and external design reviews – 1 response
• Ensure change control is well managed and approved – 1 response

Quality control:
• Improved quality control in design and construction processes – 2 responses
• Improved quality control at the suppliers – 1 response

Project management aspects:
• Improved planning – 1 response
• Effective communication in all phases of the project – 1 response

Close out:
• Involving the client in the commissioning of the plant and systems – 1 response
• Handover the completed packages as soon as they are complete – 1 response

All of the aspects are related to the performance of the EPCM Company.

6.27 Conclusion
In chapter six the responses to the interviews are collated and analysed. The analysis covers trends, topic understanding and novel responses. These analyses will be used in chapter seven that follows to draw recommendations for the revised model and to support or not the objectives and the precepts identified in chapter one.
Part 4 - Conclusion of the study

Chapter 7: Recommendations

7.1 Introduction

In chapter seven the outcomes of the interviews and the key issues highlighted in the literature reviews are analysed to generate a series of recommendations under the main headings.

From the interviews it is clear that the nature of the large multidiscipline mining project environment is changing and these changes are affecting the nature of the business for the Engineering Procurement and Construction Management (EPCM) specialist companies.

In the execution of the research for this thesis the scope of some of these changes were apparent and revealed particularly during the interviews.

In addition to the changes in the EPCM Company and mining project environment there is a propensity for mining projects to ‘fail’ in at least one of the performance measures for a project, this was revealed in the literature review.

It is therefore incumbent on the successful EPCM Company to mitigate this tendency for failure to the benefit of the client and to ensure the EPCM Company benefits from participation in the project execution process.

7.2 Project leadership

7.2.1 Project leadership – introduction

Fundamental to the successful running of a project is the selection of a good leader or leadership group.

EPCM Company project management has four aspects:

- The project team both in the office and in the field,
- The stakeholder group outside the project team,
- The head office politics and administration aspects,
- The project execution.

There has been a large quantity of literature written about leadership and leadership styles in management. In project management there will be a variety of demands placed on the project leader and the project leader may be required to apply the differing leadership styles of transactional verses transformation dependent on the project environment. The project leader would be required to evaluate the team performance and commitment under different project leadership styles.

The project team will require team building, leadership and conflict resolution, the project in execution will require a technical skill, contract knowledge and planning, the head office will require
administration, organisation and resource allocation and the external stakeholders will require management support building, communication and entrepreneurial skills.

The skills required of the project leader need to be examined; these would include a technical ability, a human skill and a theoretical skill, in other words an understanding of the project, leading the team and stakeholders and the ability to see the big picture of the project in its environment. The project leader also needs to be able to perform within the bureaucracy of the large EPCM Company environment where the support for the project team will come from.

The following list of criteria was arrived at from the literature review for project leader selection:

- Personnel skills,
- Project management skills, understanding the project management processes,
- Business skills,
- Technical skills,
- Quality skills,
- Decision making expediency.

7.2.2 Project leadership – recommendations

The literature reflects on the necessity for understanding the complexity of the construction project, the socio-cultural complexities of the International project add to the complexity of the project leadership group tasks.

In the EPCM Company environment a motivational/ transformational management style giving the staff a free-rein to perform their tasks and giving individuals the opportunity for development seems to be the preferred approach. This gives the project leader the operating freedom and the latitude to give guidance and take strategic decisions where required.

There is also a necessity to have a versatile and situational approach to leadership dependent on the project environment and the motivators of group of people being lead, the typical split in the EPCM Company environment would be the head office/ design office against the site/ construction environment. There was an agreement that the relative seniority of the group being lead would require a different management style or approach.

The literature also reflects on the aspect of power sharing and empowerment as opposed to the Machiavellian approach of establishing and maintaining a strong power base. Empowerment is a management approach particularly suited to the complex project, and the agile management style required in the uncertain environment of the large multidiscipline mining project.

This management style has a positive effect on the overall team performance. One respondent commented that an underperforming team had transformed into a well performing team under the influence of an open management style.

The open liberal style of management was found to benefit the team performance as most of the personnel enjoyed the greater responsibility and trust. There were times however, particularly
when the deliverables were on a tight program when the more direct ‘hands-on’ leadership style would be required.

Contrary to what could be seen as being popular opinion that the ‘project manager requires little technical skill’ and all that is required is a good grasp of ‘project management’ skills, the survey revealed that a good grasp of the technical requirements of the project was required. In practice however, according to the interview discussions, the Client project team has a technical make-up and thus would have a distinct focus on the technical aspects of the project.

In addition to the above would be the need to possess the necessary project management skills, previous project experience and the traditional management skills of; communication, leadership and team building.

For the project execution phase the project manager should also possess an excellent understanding of the project’s contractual and financial terms and conditions.

For long term client relationships there should be a good culture fit between the EPCM Company Project Manager and the Client Project Team.

Though internal administration is an essential aspect of the business of the company particularly when the EPCM Company is large and International, most of the respondents said that it was excessive. This could be excessive to the point where it becomes intrusive and starts to affect the project performance. It could also come to a point where the client sees no value in the time being allocated to this activity, affecting the future business of the EPCM Company.

This can however be delegated to responsible persons within the project team to ease the burden on the senior project personnel. Administration specialists could be seconded to the project team to administer the intercompany interfaces.

The evaluation of the performance of the project manager should examine; over and above the standard criteria of project performance, time, cost, quality - the large multidiscipline mining (LMM) project safety performance.

In addition to this, for the development of the EPCM Company the criteria should include the legacy criteria of staff turnover, team satisfaction and knowledge retained.

7.3 Project human resources and knowledge management

7.3.1 Project human resources and knowledge management - introduction

Human resources and knowledge management can be combined in one section as the human resource carries and is responsible for the knowledge management in the EPCM Company. There have been many studies executed in the field of human resource management and some of these studies have examined the effect of human resource management on the efficacy of project delivery.
In project management companies the project demands determine the deployment of the engineering resources in the company this can be divergent to the views on deployment as determined by the human resource function.

In the EPCM Company environment staff retention and knowledge management are two linked aspects, not all of the staff knowledge can be captured in a documented form. It is evident from the interview responses that the human resource and the management of knowledge are two of the core strengths of the successful EPCM Company.

From the interviews the knowledge management processes that are currently available were too complex and thus were not being applied to the benefit of the company. In addition to this the knowledge being gathered on the projects was not freely available or easily accessible for persons working on other projects. Most of the knowledge being gathered was resident in a project specific lessons learnt database. Tacit knowledge was by definition resident in the individual's personal recollections.

There was uncertainty in the company as to the policies for knowledge gathering. The policies for explicit knowledge gathering were intimated as being available but this was either not complete or sufficiently thorough.

The knowledge management processes can be condensed into the following elements:

- A defined and understood knowledge structure,
- Time, facilities and forms for knowledge sharing,
- A corporate knowledge strategy,
- Training in knowledge management,
- Information systems,
- Information storage for recovery.

Clearly; for stored knowledge to be of benefit for the company it has to be accessible, structured, relevant and understandable.

7.3.2 Project human resources and knowledge management – recommendations

It was agreed in the interviews that there was a lessons learnt process in the company that, when practised gathers some of the knowledge gained in project execution. In general, however this was not well practised in the EPCM Company.

The knowledge management policies must be expanded and properly implemented, during this implementation process the information must be captured into a common database and made easily accessible across the various company platforms.

There were no processes noted for the capturing of tacit knowledge into computer systems, in fact most of the respondents saw this as being the individual's retention tool for job security and the personnel were too busy to make any effort in this capacity. In addition, at the end of the project there was very little time to allocate to this process. Clearly at the end of a project, or as the end
of the project execution approaches there needs to be a period of time allocated to capturing tacit and explicit knowledge into the corporate databases.

In general, the divulgement of tacit knowledge was poorly managed and generally carried out in an informal manner. The haphazard nature of this process would be reflected in the poor quality and capturing of tacit knowledge. Most of the personnel involved in this process agreed that there should be more structure to the gathering of project knowledge to the benefit of the company.

There should be no impediment to the collection and collation of knowledge and this process should be encouraged and guided through specific structured meetings. In addition to the standard knowledge gathering processes the engineers and supervisors should spend more time in the field and with vendors to embed and give relevance to the learning gained in the office.

It was lamented by some that there was a significant burden of corporate administrative tasks. However, when the EPCM Company group was transposed into the client’s infrastructure then the emphasis was on the performance of activities in compliance with the client’s processes.

It is important to develop a culture that is focussed on the retention and development of top talent. Knowledge management and the retention of key learning experiences should be of primary importance to the EPCM Company as this would be a key differentiator between the EPCM Companies and a key marketing business marketing strength.

Knowledge gathering and collation should become a part of the company culture. Unfortunately, this was not seen as being of primary concern from the point of view of the EPCM Company interviewees; often the main focus is on the delivery of the project particularly when the EPCM is embedded in the client’s organisation.

It was stated by the interviewees that the knowledge management aspect of the project delivery should become a primary concern of the Project Engineering Manager and the Project Manager. To facilitate the knowledge management process there should be a champion identified for this task and this should be a senior project team member. Through this process knowledge gathering should become a primary objective of the project team and the information would be transposed into a structured database to aid the gathering, retrieval and dissemination of the data.

For this to happen effectively in the project environment it would be necessary to schedule a specific and focussed meeting. The frequency would be determined as necessary for the meetings to be effective in capturing the project knowledge. The frequency of the meetings could be anything from six months to weekly and would be dependent on the phase of the project. Typically, in the EPCM Company project cycle it was seen to be necessary for a weekly meeting, this would also serve the purpose of maintaining the team identity.

In order to effective the database has to be accessible and to the greatest extent user friendly and it is incumbent on the EPCM Company to ensure the company knowledge database is maintained front of mind and used. The more this can be achieved the more likely the database is to be effective and useable.
Projects have by definition a beginning and an end, project downsizing and disruptions are common place with long duration projects in uncertain environments. The company should be properly prepared for this occurrence and, the project disruptions and delays should be handled as a common place activity.

During period of project disruption there should be a maxim of 'business as usual' within the EPCM Company, the focus should be on maintaining business momentum and maintaining the project momentum for the client. A significant benefit from this approach would be to minimise the losses to the team members. Maintaining a core team during period of disruption is a key aspect of retaining knowledge and being able to capture this to the benefit of the company. Understandably however project disruptions will have a significant effect on the effectiveness of the project team but this has to be managed and controlled by the EPCM Company. In general, however clients have little regard for the internal business of the EPCM Company, the focus of the client must be on the business sense of the project, scheduling and costing.

Knowledge management is by its nature a view of what worked or did not work in the past; knowledge management therefore creates and entrencheds habits in the company. As such knowledge would not be seen as being the driver of innovation. In the counterpoint knowledge gathered and applied could be seen as being the release for innovation or innovative thinking allowing the engineering personnel the freedom to think more broadly.

Though not often considered as being an attractor for top talent, a well-founded company that is attracting clients through a robust knowledge database would be attractive to prospective employees; the company would be seen as being stable and capable of providing a good employment experience. The knowledge database would have the benefit of allowing employees to operate with confidence and to be able to think more freely.

In the EPCM Company it was identified in the interviews that some individuals and specific projects have policies for knowledge transfer. This process was being reinforced in the key performance indicator processes in the company. The champion of this process is however the mentoring and coaching processes within the company.

There should be specific meetings and project events planned for the knowledge transfer processes, possibly reinforced through the application of specific team field trips.

The principle ‘community of practise’ would be reinforced to the benefit of the EPCM Company and the Client through regular specific meetings and the deliberate retention of the core team in the project. This may be more applicable to the smaller company but could be equally applicable to the EPCM Company project team.

The ‘knowledge community’ the ideal position for the EPCM Company to be in as this is the matured knowledge management group of the organisation. This could also be seen as being the pitfall of many companies through only offering the ‘same old solutions’ to problems and being unable to think innovatively.
The corporate benefits of knowledge management would be the ability to predetermine solutions to problems and to be able to mitigate or eliminate the risk associated with reaching engineering solutions. There could also be a substantial reduction in cost for the client and the greater propensity for the project to be approved in the feasibility phase of the project gestation. Project sponsors would have a greater assurance and confidence that the project structuring, scheduling and costing is realistic.

The activities of the EPCM Company change during the execution of a project so in line with these changes there would be a varying requirement for personnel to be deployed into the project. Naturally there is a finite resource available from the internal resources of the EPCM Company and the specific recruitment of personnel for the project can be time consuming and imprecise.

There should be policies available for the deployment of personnel but from the interviews, this should not solely be the responsibility of the Human Resource Department or the relevant Head of Department in a 'matrix structured' organisation. The Project Management team should also be key decision makers regarding the selection of personnel for deployment into the project.

Induction into the company and into the project, according to the interviewees can be very perfunctory. For an EPCM Company the induction would, by the nature of the business of the company, on a few levels; company policies and practices, site and client induction and for mining projects safety and legislative requirements.

According to the interviews this was not thought to be done well though where the client was having a strong influence over the activities of the EPCM Company team the induction was done measurably better.

The performance of a project team is as good as the least performing person on the project team. In the management of the team the Project Manager should see the benefits of specific encouragement and the processes for managing the performance of the individuals in the team. There is scope for performance incentives but these should be within the EPCM Company’s schemes for performance incentives.

In the interviews it was identified that the individuals should be self-motivated and they should feel that their inputs are a valued part of the complete project delivery. The interviewees lamented to poor performance of the EPCM Company in this area of the business. All of the responses agreed that this is an area of the business that it is important to get right for the future success of the company.

The staff working on the projects must be kept challenged and stretched. It was intimated in the interviews that it is necessary to give personal recognition. From the interviews there was consensus that the KPI system would serve a purpose in determining recognition and reward but that this process was poorly applied.

Often there is little interaction between the human resources functions and the project once the project moves into the execution phase, this interaction would be at the discretion of the project
manager. There was consensus that the human resource functions should become more involved in the projects in execution this would assure more support for the projects in execution. Currently human resource interaction is limited to the front end of recruitment, disciplinary action and on resignation or retrenchment.

The interviewees intimated that in smaller companies the human resource function is closer to the project execution team and can exercise more involvement in the training and development of the personnel.

From the interviews there is currently no structured approach to achieving human resources involvement in the project in execution, this is currently left to the discretion of the project manager to achieve.

In the client embedded EPCM Company it was established there are fortnightly discussions between the Senior Project Personnel and the Human Resources, these discussions centre on the project delivery and the performance of the human resource.

7.4 Project teams

7.4.1 Project teams – introduction

A significant aspect of being able to execute and complete a project well is to be able to establish, develop and retain a team of diverse and yet complementary skilled people. This task can be complex as the resources to be assembled to the project resource model will involve multi-skilled engineers of varying capabilities.

The project execution team is the backbone of the project. Managing an engineering project is a complex activity involving a group of varied disciplines and varied skill and competency levels.

EPCM Companies are required to allocate finite resources as required to the projects in execution; this would not necessarily create teams as the allocation of scarce resources would take precedent. The EPCM Company can achieve significant savings for the client through a process of appropriately modelling the skills and capabilities of the engineering resources, modelling the project requirements and balancing the project teams accordingly.

An examination of research literature has identified the need to digitally socialise geographically dispersed project teams, the term ‘socialising’ is the process of converting individual tacit knowledge into group tacit knowledge. From the studies examined this can be very challenging.

There are many techniques for socialising and one technique will not manage the entire project socialising requirements. A battery of techniques would be required in order to bring the teams together and to develop the common understanding of the project and the group tacit knowledge.

Project management systems and project information, essential for keeping the project team on track and performing to a common standard is however easily transferred over the internet and company intranet platforms.
The EPCM Company must focus on developing people and not just developing more encompassing systems and technical competencies. Recent studies have shown that employee development will assist in retaining the top talent of the company and reinforcing the project teams. Employee engagement will, according to studies drive the organisation through the recession.

7.4.2 Project teams – recommendations

At the initiation of any new project or new phase of an existing project it is necessary to model the requirements for the execution team and to be able to resource the team from the available and obtainable resources.

The model for the project team is based on the scope, duration and the location of the project. Obviously the design and drafting office would not be location based and these resources could be part of a virtual project team.

When establishing a project team there is a need to introduce into the team a number of skilled and experienced resources to act as the buffer for the team and to provide the mentoring and coaching resources. In addition, these resources can act as the nucleus for the knowledge retention actions for the team and as the bridge into the greater resource of the EPCM Company.

In addition to the selection of the necessary skills for the team it was seen from the interviews that there would be a preference for team members that had worked successfully together before.

In the practical environment of the EPCM Company there are a number of constraints; the availability of the resources particularly in periods where resources are constrained, allocation to and demands of other projects, the willingness of the client to pay a premium for the more experienced and skilled resources. This would direct resource selection to what is available rather than to what is desirable. Often the Client does not see the staffing of the project as a concern for the Client but solely the obligation placed on the EPCM Company to deliver the packages and the completed project as determined by the contract documents.

There is always the employment market that can provide resources for the project execution, this can also be constrained and there is the mobilisation time delay and the compatibility risk when bringing resources from outside the company.

The identification of engineering skills has three key aspects; the qualifications and certifications of the individual, the key experiences of the individual and the social compatibility of the individual. These can be checked though a review of the qualification, the curriculum vitae and in a multi-tiered interview process. This would be reinforced subjectively from previous employment experience, direct recommendations and references.

Team deficiencies are identified primarily through poor project performance, this would generally be vocalised by the Client and the EPCM Company Project Manager and project Engineering Manager.
Using the standard metrics of the project, and through the project information meetings it should be possible to identify this poor performance as it occurs, it would then be the responsibility of the Project Manager to address these aspects as soon as possible and ideally before the deficiencies are identified by the Client.

The first response to address the team under performance should be a project level intervention.

One of the big new trends for the EPCM Company is the management of the virtual project team. Scarce resources have to be utilised widely in the EPCM Company and thus are allocated to the virtual office.

The virtual project team has to be managed using the internet, visual communication and electronic communication the application of which is wide spread and universal.

There is often no substitute for a well-planned face to face meeting with the dispersed project team and the selection of suitable regional heads who are aligned to the company, project goals and delivery expectations.

The selection of the virtual team members in particular the senior team members have to be done well, and these team members have to work to standardised procedures and hold accountability. There would be common databases for the project so all of the team members have access to the same information for decision making.

In the review of the interviews there was an even split between the yes and no when asked about the use of geographically dispersed project teams. Therefore, even in a regional environment resources are becoming more dispersed.

Where projects were using dispersed teams it was noted that much stricter control over the deliverables had to be practised and the expectations in terms of deliverables and timing had to be clearly defined.

Geographically dispersed design offices could be tasked with specific packages and taken to a point to adopt the engineering commodity approach to package development.

Socialising is a team building technique. Socialising was seen to be a process to bring the team onto the same level in the project execution and is established through a process of communication – both formal and more importantly informal where ideas and strategies can be developed.

A socialised team develops common goals and tacit understanding of the project which ultimately supports the project delivery.

Socialising new team members has to be efficient and effective to ensure the integrity of the team is not diminished.

Digital socialising is accomplished using any combination of the various electronic media. Included in this mix would be the use of the ‘digital bridges’ for the transmission of documents and the sharing of knowledge.
According to the interviewees team building for geographically dispersed teams would present a significant challenge to the EPCM Company. For specific activities it would be necessary to being the team members together in order to ensure the teams are correctly aligned, these meetings would have to be accepted as a project cost.

For widely dispersed teams it would be necessary for group or team leaders to attend specific meetings and then to align their teams accordingly.

There are common areas within the company where staff can meet and discuss topical issues. In addition to this there are company based social media sites for discussion of current company issues.

For team socialising the telephone would not be the preferred medium of communication. The telephone can be used once the communication channels have been set up. The telephone has the advantage of being immediate but where important information is being relayed an electronic mail should be sent afterwards as confirmation.

As a socialising tool the telephone did not receive overall consent, most agreed that the team links would have to be in place prior to the application of telephone for socialising. Also the responses from the interviews indicated that electronic mail is not a good medium for team socialising. Electronic mail is good for direct communication and transmitting project information.

Socialising requires the flow of a conversation that according to one case was not viable in electronic mail.

The extranet was not seen as an effective tool for team socialising. Most of the cases reviewed stated that this medium was not being used for socialising. Most of the respondents indicated that they would prefer a face to face discussion. One of the interviewees stated that this would be effective for small projects but for the larger project direct communication would be preferred. It could be seen in certain aspects of the large project that smaller elements could be split away and managed separately.

Web based project teams are certainly the way of the future, in particular where EPCM Companies have to use dispersed sought after resources the internet is key for dispersed utilisation.

As stated elsewhere the virtual project team will be one of the big new trends for the future of the EPCM Company and companies who embrace this will differentiate themselves from the opposition.

Most of the interviewees agreed that meetings can be effective places for team knowledge sharing. For busy projects this can be the most efficient form of information sharing and to ensure all hear the same message at the same time.

The caveat presented by the interviewees was that the meetings have to be well managed, effectively chaired and carefully recorded.
Some projects that have delivery pressures would have a multipurpose meeting and the project status would be an aspect of that meeting.

Most saw the necessity to retain the key staff members and the talented personnel. An economic downturn would indicate that there is not a full pipeline of projects to allocate personnel to and that there would be some significant challenges to keep people occupied. This would mean focussing the training and development into the quiet periods in the project execution calendar.

People are by nature mobile and in a period of retrenchment it would be necessary to visibly make efforts to reassure the staff that you want to retain that a retention strategy is being affected.

7.5 Complexity and uncertainty

7.5.1 Complexity and uncertainty - introduction

A portion of the literature reviewed, particularly with regard to large multidiscipline mining projects was discussing with the complexity and uncertainty of the project and the challenges that this presents to the project execution team. According to the literature project complexity is becoming more prevalent for projects in execution particularly large multidiscipline mining projects.

The literature reflects on the drivers of complexity in projects, the following four aspects of complexity were identified:

- Project system size,
- Interdependence of the project,
- Diversity in the project,
- Elements of context.

In addition to the above other authors added their groupings for project complexity:

- Structural complexity,
- Project uncertainty,
- Project dynamics,
- Project pace and,
- Socio-political complexity.

Uncertainty can therefore be seen as being a driver of project complexity. One author described risk as the known – unknowns and uncertainty as the unknown – unknowns. Uncertainty is also defined in the texts reviewed as the result of a paucity of information which can give rise to opportunities or threats.

Some of the other drivers of project complexity identified in the texts reviewed would be the pace of technological innovation and the multi-cultural environment of project execution particularly in the International Company. One author examining the construction industry reviewed the competitive necessity for managing cross cultural project teams against the backdrop of speed of project execution, cost control, quality, safety, environmental considerations, legislation and
technology advances. Therefore the effective management of complexity would be a competitive necessity.

Another author described the project execution environment as becoming so complex that the management of the project has to become more comprehensive, so much so that it would be modelled on the project characteristics rather that project being prepared to comply with the established project management rules. Certainly according to another author increasing project complexity would require greater levels of individual and corporate project maturity.

The client owner group has to be involved in the management and control of the project uncertainty and to understand the impact of uncertainty on the project execution effectiveness. What would be required is an uncertainty management culture within the project execution team. This has been divided into four attributes for uncertainty management maturity:

- Processes to deal effectively with uncertainty,
- Uncertainty management maturity – applying processes consistently,
- Management experience – evolving into a corporate body of knowledge,
- Organisational culture – dealing with project uncertainty.

Project uncertainty, according to authors, needs to be made visible so that the project stakeholders are always aware of the potential effect of uncertainty on the project outcomes.

Uncertainty management requires careful consideration for projects where the outcomes are not clearly defined and where schedule constraints require management agility.

Authors have also reviewed the complexity of stakeholder management; stakeholder management though capable of being pre-planned is often developed in project execution through a process of trial and error. The successful strategy for stakeholder management needs to be learnt and passed down in the project lessons learnt records. The stakeholder management strategy would be as unique as the project itself.

Obviously the complexities in the project make the project challenging to manage and to keep under control. There are many items to manage and a great diversity of parameters that define these items. Project complexity can paradoxically give rise to project uncertainty where aspects of the project remain undecided and unpredictable. The complex project can become unmanageable using conventional project management tools.

A significant project risk can therefore be the complex project itself.

In the execution of the project it is necessary to identify the sources of the project complexity and consequences that could arise so that these items can be managed.

It is necessary for the project execution team and the EPCM Company to understand the aspects of uncertainty regarding the scope and duration of the project and the complexity regarding the diversity of stakeholders in the project.
7.5.2 Complexity and uncertainty – recommendations

The interviews were carried out to establish a level of understanding of complexity and uncertainty, from the interviews the understanding of the term complexity was largely limited to the technical complexity of the project, only a few of the interviewees intimated that the complicated interactions when managing a multifaceted multidiscipline project would add to the project complexity. The interviewees were less aware of the organisational interfaces adding to the complexity of the project.

Though uncertainty is probably one of the biggest challenges facing the execution of the large multidiscipline mining project, this was less understood and did not receive a definitive answer even though it is, as seen above a significant driver of complexity.

The majority of the interview responses were viewing uncertainty being the incomplete definition of the project leading to poor decision making parameters. Though this would be an aspect of uncertainty it would not be a complete definition.

Generally, the interviewees understood that risk was the probability of outcomes of known factors and that uncertainty was outcome of unknown factors. Uncertainty leads to the uncertainty of outcomes and that the risk was the challenge in striving for known outcomes. Clearly a different approach would be required regarding the management of uncertainty, in the large multidiscipline mining project there will always be an element of uncertainty in the execution of the project.

The interviewees reflected on the aspects of scope variation and program compression as being significant drivers of uncertainty and complexity in a project. From the interviews this was expressed as being linked to the needs of the client and the concurrent expectations of the client. One interviewee discussed the generic project changes being a driver of complexity.

It is important to separate project complexity and uncertainty, and manage the complexity aspects of the project as being fundamental project processes. Project uncertainty even though inevitable has to be managed by the project team, in challenging the client for clarification of project design criteria.

Without a clear differentiation between complexity and uncertainty the interviewees were unclear as to the sources and consequences of project complexity. As previously project complexity originates from the four complexity drivers:

- Project system size,
- Project interdependencies,
- Project variety,
- Project elements of context.

The interviewees reflected on evolving technology challenges, financial constraints, and the compression or delaying of the project program. The only consequence proffered in the interviews was that the project staff would not always know what was required of them.
• The project is required to reach an objective by performing some actions through a network of activities.
• The project has internal structures consisting of the project team, resources, materials and equipment.
• The project also evolves over the passage of time as resources are used and aspects of the project are delivered, in the background the team members evolve.

To manage the complexity of the project it is necessary to understand that there are two main aspects to this; the technical aspect and the organisational aspect. The project complexity can have positive influences and negative influences. Project complexity can also affect the decidability and predictability of the project in execution.

The interviewees stated that the complexity would be tackled in a well-structured and well-communicated manner with the complexities being deconstructed. The project team would be aligned and key personnel identified to manage the complexity aspects.

Managing the project complexity is thus fundamental to managing the project.

Most interviewees agreed that complexity can be of benefit to the personnel in generating a more challenging project environment. The personnel would become less complacent; and be given the opportunities for dynamic communication and brainstorming or scenario planning, and innovative thinking.

Being able to manage the project complexity effectively would improve the efficiency of the project team.

Regarding project dynamics, the interviewees reflected on the changing nature of the project. Large multidiscipline mining projects are often accomplished iteratively with each completed activity influencing and forming the proceeding activity.

Interviewees reflected on the day to day adjustments to the project program and schedule required to accomplish the final deliverable of the project. These daily adjustments have to be well communicated to and assimilated by the project team otherwise there is a risk that the project will become chaotic. The changing project dynamics need to be moderated by the project management team to allow the greater project team to assimilate the changes sequentially and iteratively.

The literature also reflects on the internal dynamics of the project team that will also have to be managed by the project management team. Significant project changes can have a demoralising effect on the project team, in addition to this the project activity can be slowed down by project changes and there can be a loss of execution efficiency. From the interviews there would be a corresponding risk of errors embedding themselves in the project.

Project changes in; scope, budget, schedule, are inevitable in some scale, these have to be well communicated and normalised as soon as possible so the impact of these changes are minimised.
In addition to this the effect on specific team members has to be evaluated and the team members experiencing high workload identified and supported.

From the literature and from the interviews pacing was seen to increase the project complexity from both the design and engineering, and from the construction aspect. Design information would have to be worked through quickly and some of the information required for decision making may not be available. The risk is that this would be overlooked in the acceleration of the project only to be discovered at a later date.

Pacing could also involve the running of concurrent engineering activities, this would have a distinct effect on the complexity of the project requiring multiple streams of information sourcing and processing.

The construction activities would often require the execution of many concurrent activities with the added complexity of coordination for the personnel on site.

Information biases pose a significant challenge to the execution of any large multidiscipline mining project, biases are dealt with in other areas of this document but deserve consideration under uncertainty.

The interviewees discussed the selection of or preference for certain information, the biases from faulty measurement, poor quality information, incorrect assumptions, withholding information or the group or from an individual with a preference for a particular course of action.

Biases or asymmetry can generate uncertainty in design and development, the information required for the design input has to be good quality information so that the final output is credible.

Biases are clearly human in origin – the information biases could result from; conditioning from experiences, presentation of selected information, selective interpretation, preferential capturing or distortion of data.

It would be the responsibility of the EPCM Company to ensure the information provided for project activities is bias free, or have biases highlighted.

Project complexity can often involve the management of many stakeholder interfaces. The stakeholder group is as unique as the project itself. In many large multidiscipline mining projects, the stakeholder management strategy has to be developed through a process of trial and error but this is based on the stakeholder management plan developed for the project and the learning gained from previous projects.

Within the project environment the interviewees largely agreed that there would be specific leaders in the project team allocated to the management of key stakeholders. In addition to this there could be specific personnel in the client group with the responsibility for the management of specific stakeholders.

The skill in stakeholder management comes from continual exposure to the necessity for and benefits from this activity. The relationship management is modified to correct challenges as they
arise. One interviewee highlighted that this skill development can be expedited and enhanced through coaching and mentoring possibly by the project sponsor.

One of the interviewees highlighted that the sentiment towards the project is led by the client attitude towards the project. The communication on the project will always follow a certain pattern as the aspect of trust between the EPCM Company and the Client Group is established. As stated by one interviewee 'the stakeholder relationship building was developed from one of mistrust and uncertainty towards a trusting and professional relationship'. For a long duration large multidiscipline mining project, the Client to EPCM professional relationships would have to be established and then reinforced over the many years of project execution.

The interviewees commented on the reducing level of uncertainty during the execution of the project as the project scope becomes more clearly defined and the items on the project scope are completed. Completed items will often determine the following items configuration, and design change opportunities for the client will be reduced.

The client group interview stated that the uncertainty during the design and construction would be low as the trade-off studies would have determined the way forward for the project.

The project team should aim to integrate their activities as speedily as possible and reduce the team impact on complexity. The team need to be of sufficient size only to be able to manage the project systems in the context of the project, client interface and the project interdependences within the client group and within the EPCM Company.

The client has a fundamental role in the management of uncertainty. The interviewees agreed that the client should clarify and communicate requirements in terms of scope, budget and program early in the execution process as unclear project direction leads to uncertainty.

Uncertainty management requires regular meetings between the Client and the EPCM Company. This will assist in the development of uncertainty awareness where the Client has to be a clear participant.

One respondent stated that he would expect the client to manage the project process in accordance with the project charter and to be expedient.

There are many benefits from Client knowledge sharing in the project environment:

- According to one interviewee the client becomes more involved and empowered.
- Interviewees agreed that the client knowledge sharing ensures that the Client and the EPCM Company are aligned.
- The Client becomes involved in the package delivery.
- It elicits better decisions and can prevent costly and unnecessary rework.
- The project can benefit from lessons learnt from other operations in the client’s organisation.
The interviewees were uncertain of the definition of the term uncertainty consciousness. Uncertainty consciousness develops within the project team members as awareness of uncertainty is established and encourages the management group to continually examine how uncertainty may develop. There is also an increasing awareness of the positive and negative aspects of uncertainty and the necessity to manage and control uncertainty.

As with many project situations uncertainty can have a negative as well as a positive connotation. The interviewees saw the opportunity for the project execution team to excel in an uncertain project environment. There are opportunities for the project team to challenge the uncertainty and apply innovative thinking to clarify aspects of the project.

In addition to the technical resolution there are opportunities for reinforcing the relationship between the EPCM Company and the Client as both parties share uncertainty information and knowledge in both the formal and informal communication arena.

Uncertainty awareness develops a higher level of support and collaboration between the client and the EPCM Company, develops a more holistic view of the project, helps identify opportunities for project improvements and encourages knowledge and information sharing as uncertainty is clarified. Typically, the uncertainty would be managed by identification, acknowledging the uncertainty then allocation of responsibility to resolve the uncertainty. The change of scope would be priced and the team advised of the changes.

Uncertainty management in the broader aspect would require management as a specific process in itself. There would be an aspect of uncertainty management planning, identification of the uncertainty in the project, analysis of the uncertainty and then the response to the uncertainty. Following this there would be a reappraisal of the uncertainty to see if the uncertainty had been adequately addressed by the response.

Regarding the level of uncertainty maturity within the EPCM Company most of the interviewees were confident that this was being managed satisfactorily, though without clearly documented procedures and practices being in place for uncertainty management planning, identification, analysis and response some of the uncertainty aspects may go undetected or rely on heuristics to detect. The Client group interview however yielded a low level of confidence in the EPCM Company's ability to manage uncertainty.

In effect however both the Client and the EPCM Company have responsibilities to manage the uncertainty. The Client, from the point of view of controlling the funding and being aware of the business need for the project would be in the best position to clarify the project uncertainties.

- Develop a supportive culture,
- Collaborative, professional, respectful and professional relationship,
- Develop uncertainty awareness,
- Develop a holistic view of the project,
- Share uncertainty information,
- Develop a thorough and systematic assessment of uncertainties.

Flexible strategies assist in the development of options in areas of project where uncertainties proliferate. With experienced groups within the EPCM Company the option development would be based on the acquired learning of the project team.

The flexible strategies employed would be based on the pre-emption of the uncertainty or the immediacy of the uncertainty.

The interviewees agreed that effective uncertainty management can reduce execution team down time thus improve performance and prevent periods of chaos in the project execution.

Effective uncertainty management strategies can give the project execution team the assurance that these events have been prepared for and thus can be managed.

To be able to manage uncertainty effectively the EPCM Company would have to be able to measure the uncertainty. Being in effect the absence of information about a given risk would mean that measurement would be challenging. Uncertainty measurement was thus a difficult term for the interviewees to understand.

Should the measurement be the project execution variations or the value of the scope changes? Should the measurement be a subjective team assessment of the project complexity? To be appreciated the uncertainty would have to be costed in money, time and loss of utilisation or delayed revenues.

The interviewees understood the term granularity with regard to the work breakdown structure. It was understood that increasing the granularity increases the complexity of the project as it is possible that too many packages and elements for control would be generated. This would not necessarily increase the level of understanding and the manageability of the work packages.

Increasing the breakdown of the WBS increases the understanding of the project but this has to be traded against the increasing complexity. This activity would be best tackled by the project cost engineer, the optimal WBS element sizing would be at the point where the element can be tackled by a contractor and the order placement costing maintains efficiency.

In periods of uncertainty the design activities should be placed on hold, the design should only proceed once all of the design input data is available and verified. In an effort to obtain this clarity the design staff and the drawing office can proceed with the conceptual layouts.

Where there is an agreed scope the design activities can continue until the changes are authorised. The design and drafting office can continue with the known scope items.
7.6 Project gaps

7.6.1 Project gaps - introduction

There are at least three parties to the large multidiscipline mining project; the Client group, the EPCM Company group and the principle contractor. Gaps in understanding can exist between any and all of these parties. Therefore, the ‘project gap’ is a key term that needs to be understood, identified and addressed by the project execution team.

Project gaps can manifest in a project in many ways but from the literature there are five principle gaps; the gap between the Client’s expectations and the EPCM Company’s perception of the Client’s expectations, the gap between the EPCM Company’s perception of the Client’s expectations and the EPCM Company's translation of these expectations into drawings and specifications, the gap between the EPCM Company's drawings and specifications and the product delivery, the gap between the product delivery and the Client’s perception of the product delivery.

In project delivery the EPCM Company needs to be sensitive to the gaps that can become manifest at these stages and ensure these gaps are closed or bridged at the earliest opportunity.

The key to the management of project execution gaps are the aspects of client involvement in all aspects of the development of the project packages; from design brief, design input verification, conceptual design, modelling, and detailed design to final specification. There can also be gaps in the vendor's interpretation of the drawings and specification and the final delivery. The client involvement must include a wide group of stakeholders including but not limited to the operational personnel.

7.6.2 Project gaps - recommendations

There was a lack of understanding in the interviews as to what would constitute a project gap. Gaps are a significant project aspect that can lead to client dissatisfaction and therefore need to be identified and understood so that they can be pre-empted addressed prior to their becoming a point of dissatisfaction.

It should be understood that the principle gap occurs between the client expectations from the project and the EPCM Company understanding of what the client is expecting. The client’s expectations may not be fully understood by the client and it becomes the EPCM Company’s responsibility to ensure these expectations, stated and unstated are fully realisable and then realised.

Also from the interviews it was identified that there was a distinct difference between the understanding of the Client and the EPCM Company with regard to what constitutes a project gap. As we have seen the literature gives the following definition of what a project gap is; the gap between expectations of the client and EPCM Company understanding of those expectations, the translation of expectations in to specifications, the conversion of specifications in to deliverables,
between the deliverable and the communication to the client, and the delivery and the client’s perception of the delivery.

From the interviews the term ‘gap’ was interpreted as a program delay, lack of information, lack of funding and gaps in concept, design, delivery and performance.

There is a clear necessity within the EPCM Company for an understanding of the initiators or instigators of project gaps so they can be addressed as they develop.

One of the EPCM Company interviewees understood that there could be a lack of common understanding between the two parties, a lack of common goals, poor project definition, poor communication and a lack of available data from all sources.

From the Client and embedded EPCM Company there was less of an understanding of what a gap would be as there would not be in these groups a gap in understanding.

In order to manage a gap there has to be a clear understanding of how gaps can manifest in project execution, and how they can be detected and corrected. The closing of gaps is addressed through a process of dissemination of information and achievement of complete understanding of the project deliverables. Similarly, the prevention of gaps is through the collection of information and data from the client at the start of the conceptual design processes. Then through communication and meetings, the Client and the EPCM Groups are synchronised and the gaps in expectations eliminated.

The interviews reflected on the clear differences between the Client embedded EPCM Company and the traditional EPCM Company. In the embedded EPCM Company there was little perceived difference in the information flow during the execution of the project once the communication protocols had been established. The EPCM Company group was fully integrated within the Client organisational structures.

The EPCM Company interviewees reflected on the surfeit of information in the early phases of the project execution, this would include the control budget estimate (CBE) phase of the project when the Client involvement is at a peak. This would then taper off in the execution; this was the time when the onus would be on the EPCM Company to engage the Client in the package specific configuration discussions.

The specific Client stakeholder group involvement would be maintained until the work packages are commissioned and handed over.

7.7 Project crisis

7.7.1 Project crisis - introduction

Almost every large multidiscipline mining project will undergo some form of crisis during the execution process.
From the literature a project crisis presents a valuable learning experience for the project team and should not be feared. Nor should a crisis be a ‘project in execution’ feature that should be feared, it should rather be prepared for in advance, accepted when it occurs and normalised.

The project crisis is something that should be examined, investigated, discussed, presented and recorded in the lessons learnt register. As one author wrote ‘a crisis is a terrible thing to waste’. Naturally projects that are well defined in terms of scope, time, cost and quality are less likely to be confronted with crises as opposed to the large multidiscipline mining projects that are by implication less easy to define and are thus more likely to be confronted with crises.

The literature puts down the following steps to managing the project crisis; the mobilisation of resources and achieving a common understanding of crisis, prioritisation of the tasks to be performed, normalisation or bringing the situation into control, allocation of task responsibility or allocation of the tasks to responsible parties.

7.7.2 Project crisis - recommendations

The interviewees interpreted the project crisis in various terms and focussed neither on external nor internal issues specifically.

The project crisis could be specifically a deviation from a desired output for the project that requires a significant response from the project management team. This could initiate from issues external to the project that are outside the control of the project team, or from issues internal to the project that are within the control of the project team.

The interviewees cited crisis initiators such as industrial action, loss of a key resource or a significant change in project scope; typically, external initiators, EPCM initiators or initiators in the client’s control.

Regarding project program disruptions most if not all large multidiscipline mining projects will be subject to disruptions originating from one cause or another; this can be viewed as a crisis, and can become a project crisis if not managed. From the interviews project programs can be disrupted by State interventions, labour disputes and safety stop notices.

More significant project delays and interruptions can come from dwindling International investor confidence, falling commodity prices and economic crises affecting capital availability.

All of the interviewees had experienced a project disruption of some magnitude.

As seen in the interviews the provision or preservation of capital was a major source of project disruptions. Due to the nature of large multidiscipline mining projects the capital has to be released incrementally and as such can be affected by circumstances outside the control of the project management team. In addition to this there have been situations where the main contractor has failed due to capital constraints on other projects.

Locally there can be concerns regarding the provision of electricity and water to the project site, this can delay the start-up of the project if there have been no contingencies planned.
A crisis in a project presents many significant challenges and many significant opportunities for the EPCM Company. From the Client point of view however, this should not present the EPCM opportunity to make greater returns from the project as the client could be going through a significant financial or business confidence crisis.

To manage the project crisis, the interviewees stressed:

- The application of good project management principles,
- The transparency of the project management processes,
- The thorough application of the tested project principles of planning, risk reviews, scheduling, communication, peer reviews, cost control and change management.

The project sponsor and the project management team should be reviewing the greater and immediate project environment for the necessary warning signals that the project is approaching a crisis, the understanding was that the project in execution will display warning metrics prior to the project going into a crisis situation. These metrics should be identified during the project baseline risk assessment backed up by preparation and scenario planning. The metrics can be displayed in a project health chart or dashboard. The EPCM Company can develop suitable risk management techniques and crisis control procedures, and ensure these are understood and practised.

The development of corporate crisis management techniques including scenario planning and contingency planning will go a long way to maintaining calm and allowing the project execution team to focus on resolving the issues.

From the literature, the earlier the detection of the project crisis the easier the management of the crisis will be and the management of the crisis can be retained by the project team.

The communication should be honest and in good time so that the key stakeholders can make timely decisions based on facts. There is a necessity for open communication channels with the client and the major contractor(s).

The EPCM Company approach to the crisis should be one of accepting the crisis and treating the crisis as part of the normal processes of the company and certainly a manageable occurrence in the execution of a project. The EPCM Company should be well prepared in managing the project crisis and should move to normalise the situation as quickly as possible – this would be a key role that the experienced EPCM Company project sponsor can play.

7.8 Project failure

7.8.1 Project failure - introduction

There is a substantial volume of literature dedicated to the examination of failed projects and the mechanism of project failures.

However, from the literature - projects in themselves do not fail – human systems fail the project.
Articles written on the subject of project failures have cited the following aspects as root causes; recommendations not followed by the client or contractor team, lack of disclosure by the client, basic technical errors, lack of training and a breakdown in communication.

One article reviewed placed the project failure on the doorstep of the project manager; either not being trained or not applying the training that they have to the benefit of the project.

One of the critical sub aspects of poor project management skills is the aspect of shortcuts being taken in-order to meet deadlines such as omitting peer reviews and not addressing configuration management.

So the correct, skilled project manager has to be selected for the project using criteria discussed under the aspect of project leadership.

The project deadlines must be achievable, financial estimates have to be adequate, information has to be coherent and communicated, and the resources required for execution have to be available.

Project biases will place the project under duress from the outset and have to be avoided for the project to be successful.

Biases are built into the project during the feasibility studies and are distortions that sell the project to the financiers and decision makers. If these are allowed to propagate they can make the project execution difficult and cause unwitting failures.

There is a greater emphasis being placed on planning and ensuring the planning is accurate and in sufficient detail to support the project and decision making in the project.

In addition, literature has indicated the need for exposure of the project personnel to the client business and the construction activities on site. The designs, in order to be relevant have to be demonstrated to the client and client feedback obtained. The client personnel have to be trained in the relevant operational aspects of the final design.

Client expectations have to be tempered by the designer and communicated back to the client. There is also a necessity for the client and EPCM Company engineers and designers to shift attitudes to a common point of reference so that the parties can work as an effective team to the benefit of the project.

Tipping point failures need to be identified by the project team and time taken to address these issues to ensure that they do not become debilitating constraints.

### 7.8.2 Project failure - recommendations

When asked to describe the determinants of project failure most of the interviewees reflected on the aspects of time, cost and quality, and more specifically the aspect of poor planning, poor project control and poor execution.

The client group interviewee regarded the aspects of budget and outcomes, poor information transfer, over commitment of resources and lack of understanding project responsibilities.
For the non-technical failure indicators, the interviewees discussed the increase in non-conformance reports as being a leading indicator.

There was a diverse set of responses to the discussion point regarding the contributing causes to project failure. Most interviewees agreed that there are warning signs that a project is going to fail. They stated that the project metrics have to be such as to be able to display these failure characteristics, though the failure may be irreversible by the time the project displays these characteristics.

In the other interviews the key contributors were identified as being; poor communication with stakeholders, imprecise or incomplete design criteria, asymmetric information, unrealistic project expectations, continually changing project scopes, poorly applied project controls, team morale not managed, and poor project leadership.

Clearly there are several categories of failure contributors. Most of the interviewees reflected on the social aspects of the project failure. This included resources, management support, team moral and the willingness to submit to the project controls.

For the project team the failure indicators cited included a demoralised team and difficulties in retaining staff (an increase in staff turnover). The team morale would be affected by management structure changes and changes in scope and/or program at critical/sensitive stages in the project execution.

The Client embedded EPCM Company response included aspects such as poor team make up, poor team abilities and poor project management. This would be aggravated by excessive client involvement and a poorly performing main contractor. However, it was indicated in one interview that the key stakeholders have to participate in the project execution and that end user training in the plant operation has to be sufficient to avoid this aspect becoming a project failure.

As discussed above the project manager is ultimately responsible for the success or failure of the project. The project manager has a technical role, an administrative role and a significant leadership role. The project manager is responsible for the communication with the stakeholder groups. In addition, the project manager has to manage the project processes as well as the project controls. These controls have to be instilled in the project team, actioned and followed.

The start of the project is the most critical time in the project lifecycle and short cuts taken here impact on the execution of the project. Typical of the shortcuts taken include the basic project controls; contract establishment, project scope definition, project planning, accurate budgeting, defining specifications, and detailed design.

The planning must be in sufficient detail to allow scrutiny to identify risk areas. As the project execution priorities change so must the project planning change to reflect these changes. If the planning is in sufficient detail and is realistic then this aspect will not contribute to the project failure.
Poor planning will have a serious negative effect on the outcomes for the project. Planning according to the interviewees is the backbone of the project and without an accurate and achievable plan the project will be in jeopardy.

Regarding the categories of project planning errors, the response from the client interview was the most revealing:

- Underestimation of the complexity of the project,
- Failure to manage and achieve expectations,
- Poor WBS granularity decisions, packages are too big or too small,
- Failing to gain commitment from all project stakeholders,
- Not prioritising and aligning the tasks to be performed,
- Not providing time in the program for end user training on the plant,
- Not providing for a process ramp up time in the program from commissioning.

These considerations incorporated into the planning will ensure the completed project is operationally ready.

The global aspect and the project complexity have to be factored into the project planning. Global distribution and complexity is an opportunity for the EPCM Company to perform well and add significant value to the project execution. If the global aspects of the project are not correctly managed, then this becomes an opportunity for project failure.

It was generally agreed by the interviewees that the project execution team should adopt the change management process in order to ensure the changes are correctly documented, agreed to, costed, incorporated in the planning, and included in the business case for the project. Failure is exacerbated and expedited for the EPCM Company when the project execution team attempts to incorporate these changes in the current planning and project costing.

The remedial actions to prevent project failure include; a clear project scope, capital management, detailed and updated planning, sound communication planning and execution to keep stakeholders aligned, defined project controls, thorough peer reviews, and pertinent quality assurance.

In execution the project must be periodically re-measured and corrected accordingly.

The interviews reviewed indicated an understanding of the classical definition of tipping points in projects. Should there be too much rework and quality assurance failures during the execution of the project the execution team will become swamped with activities that are not advancing the execution of the project.

The responses received to the detection of tipping points developing in the project execution was; the project team not being able to cope with the activities on the project where normally the team would have coped easily, the project team becomes challenged by quite straightforward execution tasks. The project execution program will start to display a backlog of tasks, whilst the execution
team struggles to make progress. There will be an expanded meeting schedule and meetings will take longer than planned adding to the challenges faced by the execution team.

The cases reviewed indicated that the sources of tipping point failures were such aspects as:

- Selecting poor contractors, requiring additional EPCM Company support,
- Excessive rework of poor quality plant and equipment,
- Uncontrolled or excessive scope changes,
- Increasing project complexity.

All of these aspects increase the workload on the project execution team, possibly to the point where the project team ‘cannot cope’.

Tipping point failures need to be understood, identified and pre-empted, if necessary additional staff allocated to manage the causes of tipping points to restore the team’s ability advance the project on the program.

Regarding the culture that would mitigate the tendency for failure was the understanding that the project is a team activity involving the Client, EPCM Company and the Contractor. The team should be agile, and must have access to accurate performance data.

The stringent regulatory environment can have a significant effect on the project delivery. The interaction with the State departments has to be taken account of in the costing and planning for the project along with the provision of resources necessary to manage this interface. If the interface is provided for and adequately managed, then this should not present challenges to the execution team.

Project failure learning points have to be captured into the Lessons Learnt data bases of the company and the EPCM Company must have effective and focussed project reviews.

Individual stakeholder objectives will always have some effect on the project outcomes. It is however the responsibility of the project execution team to ensure these objectives are aligned to the project through communication, impact assessments and program reviews.

A greater involvement from the client’s operational personnel would clearly reduce the propensity for project failure. Often from the operational personnel involvement in the project delivery there is a greater commitment to the success of the installed plant.

There is a perceived risk associated with this involvement of cost and program overruns, the advantage is that there will be less risk of rework, easier plant start up/ commissioning and operator training will be better coordinated with the equipment suppliers.
7.9 Project success

7.9.1 Project success - introduction

This thesis is searching for a new paradigm for the definition of and improved assurance of project success for EPCM Companies thereby improving the propensity for project success for the client. The literature reviewed is unclear as to what constitutes a successful project or indeed what constitutes a failed project.

As such there is no clarity as to what set of actions can lead to a successful project, the omission of which would in all likelihood lead to a failed project.

Also as there are two or more parties to the execution of a project, each could have their own success criteria which if satisfied would lead to a successful project outcome for that party.

The EPCM Company and also presumably the Client need additional criteria to measure the success of the project over those well established in the project literature.

Literature suggests that the following criteria are critical; clear goals and objectives, end user commitment and adequate funds and resources. In addition, the following factors need to be in place; communication, client consultation, client acceptance, top management support, schedules, planning and a project mission.

Other literature states that; a lack of cooperation, limited trust and ineffective communications lead to an adversarial relationship between the stakeholders in the project. The partnering for success is therefore a critical starting point for a successful project this includes; the provision of adequate resources, top management support, trust, commitment, communication, coordination and mature conflict resolution.

Critical success factors should be agreed up front with the Client, typically these would include; no schedule overruns, no cost overruns, optimal project performance and meeting customer plant performance criteria.

Analysis of the contemporary literature identified the following aspects for the engineering industry; project plan development, scope definition, activity definition, cost estimation and budgeting, activity sequencing and schedule development.

7.9.2 Project success - recommendations

As in the definition of project failure there was no clear definition of project success in the literature. There was also from the interviews clear gap between the Client definition of success and the EPCM Company definition of success.

The traditional metrics of project success should be taken as a base line of success for a project; completing the project scope, completing the project on program, achieving the required quality, completing the project on budget and completing all of the tasks without injury. From the interviews the EPCM Company should see the necessity for three linked sets of metrics as shown in table 7.1 below:
Table 7.1: Linked success metrics: Author derived

<table>
<thead>
<tr>
<th>Project Metrics</th>
<th>EPCM Company Metrics</th>
<th>Client Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
<td>Client satisfaction</td>
<td>Enhanced business performance</td>
</tr>
<tr>
<td>Program</td>
<td>Team development</td>
<td>Enhanced productivity</td>
</tr>
<tr>
<td>Quality</td>
<td>Knowledge developed and retained</td>
<td>Enhanced or maintained production</td>
</tr>
<tr>
<td>Cost</td>
<td>Enhanced company image</td>
<td></td>
</tr>
</tbody>
</table>

Minimal post close-out changes

Zero safety incidents

From the EPCM group interviews it was determined important from a company point of view and for the project execution team to identify, measure and display the project successes. This will often be done through a project specific ‘dashboard’ or information centre.

From the Client group interview the project success are communicated to the entire project team. The achievement of schedule, cost and quality aspects are taken as given and only the benefits accrued from implementing the project are discussed.

In the mining industry the achievement of safety goals and production targets are displayed and widely distributed, this must be acknowledged during the execution of large multidiscipline mining projects and adopted as a project metric.

Large multidiscipline mining projects are by their nature partnerships of two or more parties. The project partners have to have the same information to evaluate and to make decisions from regarding the status, success and direction of the project.

This can only be achieved through communication, common planning, coordination of efforts and a common understanding of the project definition and scope.

One interviewee reflected on the need for the definition of the battery limits, definition of responsibilities and definition of the key deliverables. In general, however the definition of the critical success factors for the project were not seen as being of a direct benefit to the project execution team as they lack the specific guidance, these aspects would have to be separated and the success factors made realistic and project specific.

The execution of projects in the International arena is as we have seen, one of the big new trends in the EPCM Company environment. The successful EPCM Company of the future will be the EPCM Company that can best apply the strengths of the company across International boundaries. International EPCM success factors would have to be identified and applied as a project success metric.
7.10 Conflict management

7.10.1 Conflict management - introduction

As with many fundamental aspects of project management there have been many studies executed and books written that deal with conflict in the workplace and in business management. Conflict is inevitable and to a certain extent essential for the achievement of the goals of the project. Conflict can if not managed effectively, according to the literature, be expensive and time consuming so it is to the benefit of all involved in the project to ensure the conflict is resolved quickly and effectively.

The big new trend into the International project management arena has, according to the literature, introduced more potential for conflict and has made conflict resolution far more challenging for the project management team. The International project can either be resourcing the project team from an International human resource or working on projects that are away from the home base of the EPCM Company. As seen in the context literature the International project can introduce more than just language and cultural challenges but also introduce a technical understanding and different contracting practices as challenges amongst others.

The project team needs to adopt a non-punitive approach to the resolution of project conflict. People need to be separated from the project problems and there are well established models to manage these situations.

It is important to ensure the potential for conflict is reduced through effective common systems and a common project understanding, and that conflicts and the opportunity for conflicts are identified as soon as possible and managed.

7.10.2 Conflict management - recommendations

All of the persons interviewed have had project conflict experiences. These conflicts were in the main project based, some were technical disagreements and very occasionally personality clashes. Two of the interviewees reported conflict with the client, with one interviewee reporting significant conflict with the client.

The interviews gave a wide variety of responses to the causes of conflict - project based, technical and personality origins: disagreements came from interpretation of specifications, scope changes, invoice certification and project bonuses, contract interpretation, negotiations for presentation to the company board, blame allocation for project failings, management changes in the client camp, personality clashes, unclear or poorly defined responsibilities, conflicts between the client and the main contractors and disagreements in the execution team.

There can be conflicts between the Client and the EPCM Company regarding leadership responsibilities, contract interpretations, scope, schedule, costs and communication.

There can be conflicts between the EPCM Contactor and Sub Contractors regarding progress interpretation, rework and quality standards to be applied.
There can be conflicts within the EPCM Company regarding skills, resources, personalities and program.

The sources of conflict in a project environment are minimised though the application of the basics of good project management namely - proper project initiation with procedure writing, proper project planning with sufficient detail, executing the base line plan, managing the changes, monitoring progress and comprehensive communication to the stakeholders.

In the EPCM Company environment team selection and team socialising are important to ensure the team understands each other, understands the project scope and works well together. However, the Client and EPCM Company interface needs to be managed ensuring the contract is fair to all parties and the scope of work is clearly defined and agreed.

Changes need to be agreed and documented through effective change management, and regular meetings are required to ensure all the parties are correctly aligned.

Regarding the detrimental aspects of conflict, the interviewees identified and agreed on the following characteristics:

- Demotivation, loss of morale,
- Loss of key personnel,
- Delays on the program,
- Strained communication channels,
- Breakdown of trust.

As stated previously it is essential that the points of conflict are identified and resolved in good time so that the detrimental aspects are effectively mitigated.

Regarding the positive aspects of conflict, the interviewees remarked on the following in project environment providing it is managed correctly:

- Issues are aired and resolved,
- Conflict shows project commitment,
- The contract gets reviewed,
- Encourages honest communication,
- Resolves accountability,
- Increases the positive energy in the team,
- Project personnel become experienced in identifying and resolving conflict situations in the future.

The interview responses received regarding conflict resolution were generally text book resolutions. The conflict could be between two individuals or between two companies.

The interviews yielded the following potential sources of global conflict:

- Poor definition of the requirements,
- Differing technical standards,
• Communication challenges,
• Language and cultural differences,
• Team socialising incomplete or insufficient, no common understanding of the project,
• Poor team alignment to the project goals,
• Insufficient skilled or experienced resources,
• Stringent completion criteria and program pressure.

The following technical conflict factors were presented by the interviews reviewed:

• Inadequate information flow,
• Gaps between the client expectations and the EPCM Company delivery,
• Delays in decision making,
• Communication and culture barriers,
• Different health and safety practices,
• Local legislation and licensing,
• Differences in local standards,
• Local project environmental conditions.

The interviews yielded the following as basis for resolution:

• Clearly identifying the points of conflict,
• Agreeing the conflict resolution and resolution strategy,
• Agreeing the program and review date, monitor progress and close out the conflict,
• Ensure the resolution is the best for the team and the project,
• Documenting the process followed and the resolution.

The starting point for resolution from the interviews was to agree and establish a common set of project standards and a clear package list and schedule. This will provide the foundation for the project. The communication strategy, channels and primary language must be agreed by all parties.

A conflict resolution method needs to be set up with the parties responsible for the conflict resolution. Conflicts need to be identified early and made open for the senior team members to resolve. The conflict needs to be addressed quickly and a speedy resolution found and agreed.

Global procurement initiatives can be a significant source of conflict in a project. Where the team is properly prepared for this and there are some experienced practitioners in the team this should not present challenges, but where this is not the case then there is significant scope for conflict.

The interviews reflected on the new logistical challenges, the language barriers presenting communication challenges, the lack of experience and trust. These aspects may reflect in the product delivered and the extended time lines for delivery to site.
7.11 Project management philosophy

7.11.1 Project management philosophy - introduction

Project management is becoming more and more challenging, projects are becoming more and more complex and clients are becoming more discerning, demanding improved services, implementation of new technology in all aspects and greater reliability in project delivery. As the EPCM Companies become more dispersed, communication and coordination is becoming more challenging and the transfer of information more challenging.

There have been a few studies into the fundamental philosophy of project management and the continuing applicability of some of the well-established project management principles.

Basic project management principles are, according to some authors embedded in our culture and ask the question, that if this is so then why do so many projects fail?

The application of the project management process should not be thought of solely as the mechanistic delivery of a technical solution to a client but also as being the delivery of a benefit to the operational aspects of the client’s business and creating a legacy beyond the project for the client and the executing parties.

The EPCM Company will not necessarily benefit directly from the completion of the successful project so would need to manage a different set of success metrics and ensure these deliver a clear benefit to the Client regarding project success.

7.11.2 Project management philosophy – recommendations

From the interviews the industry was looking for a common standard to apply to the practise of project management and the Project Management Institute developed a ‘best practise’ based PMBoK® guide that has achieved widespread International recognition and support.

The PMBoK® guide has given project management a set of criteria for the control of projects and, a set of guidelines for the direction of project management activities and for the training and evaluation of project management personnel.

The large multidiscipline mining project is subject to many forces in execution that can have an effect on the scope, budgeted costs and project schedule.

During the project viability discussions the ore body can be incorrectly evaluated due to incomplete information, coupled to overenthusiasm and a keenness to have a new project in execution. This would be the bias to overestimate the value of the project.

The PMBoK® way has established a common framework for the execution of projects, but from the interviews it is essential that the framework is applied judiciously.

There are certain aspects of the large multidiscipline mining project that require specific consideration, and there are key aspects of the EPCM Company involvement and the Client benefit that also require specific consideration. As we have seen elsewhere, with the large
multidiscipline mining project the project management processes may have to be formed around the project.

Though the application of the PMBoK® way will go a long way to assuring project success it will not necessarily assure success for the EPCM Company and for the Client. The EPCM Company not directly benefiting from the completion of the project will be required to apply additional criteria to ensure there are residual benefits and for the development of the EPCM Company assets.

7.12 Last planner

7.12.1 Last planner – introduction

The literature reviewed expresses clearly the need for thorough, accurate and evolving planning as a fundamental activity that will support project success.

The literature referring to the ‘last planner’ approach is one where the last planner in the chain of planners is the one who adds the detail to the plan prior to execution. The ‘last planner’ is by definition not involved in the whole planning process and therefore may not be aware of the whole project plan but will be able to add the detail and provide the execution team with the information required for execution. The last planner approach, according to the literature is able to improve the productivity of execution by 10 to 40%.

In addition, the last planner will also maintain a buffer of tasks for execution. This will keep the execution teams busy, if there is a sub-optimal condition existing in one work area preventing access or progress another will be available for work to commence or continue.

The last planner approach can also optimise the downstream work flows, reduce the large material stockpiles on site thus minimising the capital ‘lock-up’ in materials waiting for installation and commissioning.

Though the last planner is a rolling planning technique, accurate and honest planning is in the literature critical for efficient project performance.

7.12.2 Last planner - recommendations

The interviewees reflected on the lack of detailed and realistic planning available at the start of the large multidiscipline mining project. The large multidiscipline mining project team should be allowed a couple of months at the start of the execution phase to set up the project. The project execution should be initiated with planning to a level of resource loading but from the experience of the interviewees this is often not the case.

Typically, at the start of a project the contractors’ detailed planning is not available; the contractor’s planning in the tender documents would be at a best draft and an ideal program, thus not necessarily representative of the actual execution scenario and would not have taken into account the execution and material constraints.
Thus according to the interviewees the ‘base line’ project plans available at the initiation of the project would be the high level and optimistic (biased) board approved plans. The planning horizons reflected in the interviews were very much dependent on the role of the individual in the project environment.

- The Client project manager would typically look at 30 to 50-year horizon to a detailed monthly plan.
- The EPCM Company project director would look at 10 years to a day in an execution program.
- The EPCM Company project manager would look at the project duration, a financial year down to possible micromanaging of specific critical tasks on an hourly basis.
- The Client embedded EPCM Company project manager would generally work within the client’s directives for planning and reporting.

There was no indication in the interviews of a planned buffer of tasks made available for the construction teams. In the large multidiscipline mining project there are often a few areas where work can be executed so there would be by definition a buffer of tasks available for the execution teams. Effective use of buffers, especially in underground construction would require a versatile construction team and additional plant and materials.

Should the contractor fall behind the EPCM Company material procurement program there would be a buffer of materials available for construction.

From the interviews should the project be under pressure and should there be financial constraints there would be less opportunity for the project to have a buffer of areas available for construction and a buffer of materials for the construction teams.

In the EPCM Company environment the task completion was monitored by the supervisory resources available on site. The information collected is then recorded by the planner on site and reported back to the project management team in the general and specific progress meetings.

In some projects there is a need to monitor and report the allocation of resources and hours utilised against the planned resources and hours. This activity is particularly relevant in the embedded EPCM Company group where there is a greater emphasis placed on the EPCM Company performance regarding package completion and discipline performance; this is then reported back into the Client structures at various levels.

In general, however, there was no application of the last planner principles in the study interview group. It was indicated in the interviews that there is a relative paucity of skilled planners and it is understood in the current project environment there is no scope for multiple levels of planners. The large multidiscipline mining project although being long duration is generally not complex enough to support multiple layers of planners.
From the interviews however there was an understanding of the principles of the last planner as there was an addition of detail to the project plan and the specific package planning as packages approached execution. This process could be project initiated or could be execution initiated.

7.13 Agile project management

7.13.1 Agile project management - introduction

According to the literature reviewed there has been an increasing focus in the past decade on an improvisational and agile approach to project management. The conventional approach has according to authors been falling short of expectations due to the greater pressure on the efficient allocation of capital and the expectations for quicker returns on the committed capital, hence pressure to cut program durations in all aspects of the project delivery. The large multidiscipline mining project is possibly the definition of a turbulent, incompletely defined project and thus less likely to fit into the mould of a well-defined ‘conventional’ project.

Companies have to be able to respond quickly to the market challenges and to support this paradigm; business development projects will have to be similarly responsive.

Agile project management is the antithesis of project management through process and control. Creativity, intuition, innovation and bricolage would be the four pillars of agile project management. According to the literature the agile project model includes the following five steps; envision, speculate, explore, adapt and close. In parallel with this ‘bricolage’ can be employed; defined as ‘making do with what you have to hand’.

In the adoption of ‘agile project management’ it is essential to keep good record of the iterations followed to arrive at the desired solution for any future dispute resolution, billing and importantly – recording the lessons learnt.

Agile project management is probably the most important of the big new trends in the large multidiscipline mining project and EPCM Company environment, and certainly needs to be reviewed and adopted by both the Client and the EPCM Company groups for success into the future.

Project execution agility allows the EPCM Company and the Client groups to respond to the strategic changes that the project will be subjected to and to the vagaries of scope revisions particularly where the project scope cannot be clearly defined.

7.13.2 Agile project management - recommendations

From the interviews there is a clear necessity to extend the definition of the project beyond the standard definition of:

- A defined start and completion date,
- Defined objectives,
- A defined series of activities,
• A defined budget,
• The application of project principles.

This standard definition only describes the project from the project execution point of view and ignores some of the requirements of the Client and some of the requirements of the EPCM Company with regard to the project outputs, legacies and deliverables.

The Client definition of a project would include the completion of a project that will add value to the operations of a company. The EPCM Company would require the enhancement of project execution assets and development of relevant project execution artefacts.

In the large multidiscipline mining project environment there has to be an application of ‘agile project management’ principles. The project execution team has to have a group of experienced personnel and an appetite for flexibility; this gives the project execution team the ability and confidence to be able ‘work around’ the project challenges and scope or program changes.

From the interviews the value of ‘agile project management’ abilities were seen to be significant particularly where the project scope was not clearly defined. In the large multidiscipline mining project environment this is often the situation faced by the execution team.

The interviewees intimated that the scope is seldom fully defined at the commencement of the project and project execution would require the application of innovative project execution techniques. With rolling requirements and project clarification the scope definition can be done incrementally and with the application of agile project management systems allowing dynamic project management techniques the project team could be effective and keep the project on track and on budget.

In implementing agile project management techniques there would be a requirement for an experienced and agility focused and capable project team. There will be times in the execution of the project where deadlines will be demanding; in these times the well-established and mature team will be an aspect of project success.

Even though the scope is not clearly defined the schedule key dates for the project and the project budget will be defined – the project still has to be of strategic benefit to the client on completion and comply with the client business plan.

By implication the client will also have to be agility focussed and accept the rolling scope definition that is contingent with mining projects. The Client group would have to work closely and cooperatively with the EPCM Company teams.

Agile project management tactics are of advantage when the internal aspects of the project are uncertain and also when the issues external to the project are volatile and thus uncertain. The agile project management approach has a profound need for good project management skills in-depth and a good understanding of the initial project scope and in particular the changing project scope.
In addition to this is the need for good communication strategies for the project stakeholder alignment.

Agile project management requires tolerance from the EPCM Company and the client alike; this tolerance would be reflected in the systems of the EPCM Company which would be amenable to agility and flexible to allow the project execution team an amount of implementation freedom.

As discussed above, critical to the success of this approach would be a client who is amenable to the agility approach to project management. The client would have to be approachable and available for greater periods during the project execution.

With an incomplete scope there is also the possibility of situations where the scope will change unexpectedly, in this condition there would be a necessity for an improvisational project execution team capable of working around the situation and still being capable of meeting the project deadlines.

There would also be situations where tasks can be broken down into smaller tasks that can be managed in an improvisational manner rather than in the traditional pre-planned manner.

Improvisation was viewed by the interviewees as a technique for being able to adapt to the changes in the project execution and deliverable. This would be both in terms of the project management techniques and the technical deliverables of the project. This gives the project group the opportunity to think innovatively and also apply previous experience and knowledge to the project execution.

According to the interviewees in the large multidiscipline mining project environment this technique would be invaluable as it gives the team the opportunity to keep the project on track.

The principle challenges from adopting agile project management to the project implementation and technical execution was seen to be the aspect of communication and the need for an experienced and a well-established and cohesive team.

The project execution environment will also need to have flexible procedures and flexible communication channels, it was seen by some interviewees that this would to a certain extent preclude globally based and virtual project teams.

Clearly where the project can be clearly defined it should be clearly defined. In a cautionary note though; agility should not allow key project activities to be overlooked and the necessary controls need to be applied more rigorously.

7.14 Project systems

7.14.1 Project systems - introduction

In a company that specialises in project execution there is a great benefit to be gained from the adoption of project management principles throughout the company. This will create a common sense of purpose throughout the company, and a common understanding of the business of the
company. Adopting project management principles will also have the benefit of identifying and generating new resources for the project execution teams in the ‘front line’.

Adopting the philosophies project management as a core competency in the organisation would provide the framework for the effective implementation of other company wide improvement initiatives.

According to the literature some of the world’s best companies are adopting project management principles as a way of working; this should of course have a fundamental ethos of creating a lasting legacy beyond the mechanistic creation of change.

7.14.2 Project systems - recommendations

From the interviews it was indicated that the EPCM Company does not necessarily apply project management principles throughout the whole company. The non-project resources would be managed in accordance with the best practices for that particular discipline.

One of the interviewees stated that the resources for the project execution would be selected from the matrix of the structures within the company and that the support departments are not seen as being integral to the project delivery process.

This is contrary to the concept of holistic project delivery where the whole company would be geared to the project delivery process, even where the department is supporting the project delivery process and not necessarily seen as being directly involved in the project delivery process. This would apply equally to the structures of the EPCM Company embedded in client organisations.

Clearly the EPCM Company would benefit from the adoption of project management principles across the company. All of the employees would appreciate and understand the core business of the company and the versatility would enable temporary or permanent placement into the project delivery team.

The Client would have a greater confidence in the non-billed operations of the EPCM Company supporting the project even though the support groups are not necessarily seen as being directly involved in the project execution activities.

7.15 Project control in uncertain environments

7.15.1 Project control in uncertain environments - introduction

As discussed previously project uncertainty is one of the drivers of project complexity. From the contextual articles reviewed increasing project complexity is a feature of large multidiscipline mining project execution in the modern global economy and global project execution environment.

A change in thinking is required for project control in uncertain environments; not moving away from the traditional project management style will result in increased anxiety, particularly about roles, in the project team members. At the same time as there is uncertainty the project must
deliver to the client’s expectations. The project management team have to continuously strive to bring the project into control despite the project tending to chaos.

The drivers of uncertainty in the large multidiscipline mining project arena are key areas that need to be identified, attended to and resolved at the project level before they become the source of poor performance. Typically, uncertainty in the project is driven by information load, ambiguity, complexity and turbulence.

From the interviews a typical senior management reaction to uncertainty is to identify this with a project that is out of control and then attempt to regain control of the project; often in doing so, there is a corresponding increase in instability and chaos in the project.

The environment of the large multidiscipline mining project is best described as ‘chaordic’ or organised chaos. The ‘orderly chaos’ requires a different management approach to accept and steer the project to eventual ‘on schedule’ completion. Management is required to establish and maintain their contact with key stakeholder in the organisations represented in the execution of the project, monitor the history of the project and apply a ‘push forward’ strategy.

In the reduction of the project uncertainty the following aspects should be considered and addressed; ambiguous, incomplete and vague information, complexity and turbulence (instability and randomness).

In addressing uncertainty, the project managers need to be vigilant and flexible, and manage the key stakeholders effectively.

7.15.2 Project control in uncertain environments - recommendations

From the interviews it was suggested that main sources of uncertainty in projects originates from the three aspects of; project scope, delivery and program. In addition, there were aspects such as lack of clarity regarding the client requirements and the work to be performed. This would be compounded by poor communication and poor planning.

Other interviewees saw the project budget cuts, scope changes and mid-term changes in the principle contractor as being contributors to project uncertainty.

The EPCM Company interviewees stated that the client was seen as being the principle driver of uncertainty in the project; uncertain of the expected outcomes for the project, keeping project options open, not providing the necessary leadership or direction for the project.

Regarding project information; there could be too much, or too little or too much inconsistency in the information provided. One EPCM Company interviewee stated that the efficient project team has clear goals and a well-defined program, when this is not the case then the efficiency of the project team is lost.

Uncertainty generally precipitates poor decisions or no decisions being made, these result in the EPCM Company team not being given the required guidance from the client. Decisions have to be made on the information that is to hand and this has to come from the client. With direction the
EPCM Company team can proceed. From the experience of the interviewees the mining industry is well versed in making decisions with incomplete information. The decisions taken have to contain the latitude for future options.

Deviations to the established project plan make resource planning for the EPCM Company more challenging and as such affect the business of the EPCM Company. Resource loading affects the billability of the resources assigned to the project, and as such is a concern for the senior management and the project manager.

The traditional matrix structure has no direct influence on the execution of the project in an EPCM Company structure; matrix resourcing can however support the project in providing resource smoothing where uncertainty requires resource shedding. The matrix structure will also provide a peer group for consultation and direction.

Senior management was seen by some interviewees to take the ‘big stick’ approach to managing the project resourcing particularly when there is a deviation to the established project program.

In general, EPCM senior management becomes frustrated in periods of uncertainty; uncertainty is seen as risk and as such requires a response from senior management. Thus there is a propensity for senior management to become directly involved in these times which is probably not what is required. The project itself is not in trouble but the team is responding to the uncertainty.

Senior management should be involved in gaining clarity for the project team through liaising with the project stakeholders and improving the project communication if required.

Uncertainty can originate from the project, from the EPCM Company environment and from the greater environment.

Increasing uncertainty according to the interviewees is reflected in the team with a developing loss of interest and demotivation. The perceived individual security is affected; therefore the communication with the team has to be honest with a full appraisal of the project status. Uncertainty and the increased requirement of agility and innovation may not suit all of the team members.

The interviewees reflected on the need for more communication with the team members and increased consultation with the client. Meetings need to be more frequent, the meetings with the client should focus on the resolution of the project uncertainties. The emphasis has to be on finding aspects of the project which can be determined as being certain and focusing the resources on these established project deliverables.

Indeed, there should be significant management effort placed on normalising the project uncertainties as according to one of the interviewees uncertainty is a standard in the mining industry.
7.16 Managing multiple projects

7.16.1 Managing multiple projects – introduction

The ‘multiple project’ scenario is another of the big new trends in the large multidiscipline mining project environment. As a definition the large multidiscipline mining project could be viewed as a multiple project as the delivery of mining project often involves working on several quite different interrelated projects at the same time. This aspect of the large multidiscipline mining project introduces a level of complexity to the project that is often not appreciated when viewed from the outside.

It has become necessary, in the interests of the Client to manage multiple projects, or to manage a connected portfolio of projects for the same client organisation.

This complexity presents a considerable challenge to the person or persons managing the projects; the priorities for the resources, managing the cross-functional interfaces between the project elements and managing the communication are examples of the complexity drivers.

In the EPCM Company organisation there is often the necessity to coordinate the project portfolio, and also the intimated consequential loss of the propensity for organisational learning and knowledge retention. The EPCM Company has to ensure that, as described elsewhere in this study, there are robust procedures in place for stakeholder alignment management, communication and control, and for learning and knowledge management.

It should be understood that the problems associated with managing multiple projects; typically, the large multidiscipline mining project is far greater than the sum of the problems of the constituent projects.

7.16.2 Managing multiple projects – recommendations

From the interviews most of the interviewees understood the ‘multiple project’ environment and the complexity that this would introduce for the project manager and that it would also be easier to manage a series of projects for one client that to be expected to manage a series of projects for a series of dissimilar clients.

The Client would often see the complexity of running the multiple projects, but the embedded EPCM Group would not necessarily appreciate the complexity inherent in running multiple projects from a construction and design point of view.

The running of multiple projects presents significant challenges particularly with regard to the management of multiple stakeholders, controlling multiple unsynchronised schedules, managing the resource allocation, the complexity of the team structures required and the complexity of the project communication. The project manager would have to be able to prioritise the allocation of scarce or shared resources to the projects and maintain a focus on the projects under his control in order to be able to identify the risks and manage these in good time.
From a positive viewpoint there would be the opportunity to be able to allocate resources to ramping up projects and take resources away from projects that are going into a quiet period or subject to program delays. So within the projects the project manager would be able to schedule resource allocation.

From the interviews the management of multiple projects would require a project management team that is exceptionally capable, particularly in the field of prioritising and delegation. It would also be necessary to be able to apply a standard set of operating procedures across the projects. Often in the mining industry the client would prefer to impose their own operating procedures where applicable, thus it would be preferable to group the projects into client portfolios.

The interviewees indicated that the EPCM Company did not have the necessary procedures to support the project manager engaged in the daily management of multiple projects.

Some of the interviewees did not view the project they were working on as being a multiple project. Indeed, some of these mining projects could be managed as a single project entity.

From the interviews it was identified that the EPCM Company should have mature and well entrenched systems for managing the cross project support systems such as finance, procurement and human resources.

The EPCM Company should also have a good resource pool and through selective employment, be able to staff the project effectively and quickly. The discipline HoD’s must be involved in the projects and understand the project requirements. The project team established must be flexible and versatile to be able to respond to the changing demands of the projects in execution.

7.17 Relational contracting

7.17.1 Relational contracting – introduction

As seen in the literature review relational contracting requires a high level of maturity, trust and stability in the Client, EPCM Company and Contractor relationships.

The relational contract is defined and an informal agreement sustained by the value of future relationships, these can be within the firm or between firms. The relational contract is based on trust and the willingness to build partnerships. This is typically relevant to the Client where the sophistication modern plant exceeds the ability of the Client organisation to sustain the resources required to maintain this plant.

There are versions and derivations of the ‘relational contract’ a typical example would be between electrical, control and mechanical equipment suppliers that would need to cooperate to supply a piece of plant to the Client, such as a mine winder plant.

Relational contracting can thus be seen as being of mutual benefit to all parties where all parties will benefit from the success of the enterprise.
As intimated above the concept of relational contracting can be extrapolated to relational employment and relational consulting. This is where the EPCM Company can see the value in external resources but would not necessarily want to sustain these resources within the company.

7.17.2 Relational contracting – recommendations

From analysing the interviews there was not a universal understanding of the term ‘relational contracting’. Therefore the intent and benefits of relational contracting were not being made available to the projects being undertaken.

Even so, it was understood from the interviews, most would understand the benefit of developing a working relationship with key suppliers and original equipment manufacturers. This would be particularly relevant to the strategic plant equipment suppliers where support would be required to maintain this plant at uncertain times in the future.

Relational contracting requires consent from both parties to this open contracting agreement. The relational contract could be seen as developing a contract based on trust, good faith and a mutual understanding of the benefits of this partnership.

There is an opportunity for both parties to gain significant benefits from relational contracting; this process would require the full support of the Client in accepting an extended, unpriced single supplier contract. Typically for mining plant, the context of this support could be from the provision of spares, on-site support and a continuing technical consulting and design support.

The benefits to the project can far outweigh the cost associated with the relational contract; preferential rates could be negotiated where there is an assurance of future business. The losses incurred due to strategic plant down time on a project can far exceed the costs incurred due to the ‘relational contract’.

In addition to the material aspects of the relational contract there are significant benefits from the mutual interest in the success of the project. This can secure a significant ‘expected value’ in the outcomes of the project from the parties involved in the relational contract.

In the interviews there was a similar lack of understanding of the term ‘relational employment’; relational employment would to a certain extent be more difficult to interpret in the project environment.

The philosophy of relational employment would be the same as relational contracting. The specialist resources would not be on the full time staff of the EPCM Company but would be available on short notice to supplement or support the resources of the EPCM Company.

This could also be reviewed from the Client perspective where resources are secured from the EPCM Company to be embedded in the Client’s infrastructure.

Similarly, there was a lack of understanding of the term ‘relational outsourcing’ in the project environment though it is probably practised by most Project Managers and Project Engineers in the execution of the project.
Most certainly in the execution of the project not all of the skills required for the completion of the project would be available from within the EPCM Company. These resources could be secured by relational outsourcing; this value of the relationship would assure the availability of these resources to the project. The availability of these resources would be improved should the contracting terms and rates be understood and accepted up front.

7.18 Fast-tracking

7.18.1 Fast-tracking – introduction

‘Fast-tracking’ is a common process in project execution to compress or reduce programs using various techniques. The techniques can include compressing time line through working additional hours, reducing activities, adding resources or running activities in parallel.

Mining projects can involve the application of significant amounts of capital that can be applied in various locations in the client organisation. Capital is applied to projects to either; sustain the business of the client, to improve the productivity or to expand the business. It is therefore common and often necessary improve the effectiveness of this application through fast-tracking, thereby gaining early returns.

Fast-tracking can introduce risks with regard to; incomplete designs, resource stretching, key control steps being bypassed and cost increases.

The benefits of judicious fast-tracking of key project packages can be earlier returns and greater team efficiencies, reduced exposure to the vagaries of the market and the ability to optimise exposure to potential cost savings with material or commodity suppliers.

The EPCM Company should focus on optimising fast-tracking activities with such optimisations as plant design for modular construction and mine design to facilitate early commissioning of the shaft system and earlier ore body exploitation.

7.18.2 Fast-tracking – recommendations

The term, fast-tracking is well understood as a technique to either catch up on a lagging program either from slow progress or due to a delayed start, to achieve an earlier return on the capital through speeding up the project delivery or to correct an underestimation of project phase durations.

The techniques tabled in the interviews included; removing float from the program, adding resources, working longer hours, running tasks concurrently and adopting a design as you go strategy. These techniques are not without scheduling and logistical risks and require a team with in-depth project experience.

Fast-tracking can make plant available for the completion of the project or make plant available for early commissioning and earlier returns.
Project opportunities present themselves during the execution of the project; this could be a low steel price or the availability of a particular key supplier’s workshop. The reduced cost presented by this could be to the advantage of the project, packages could therefore be fast-tracked to take advantage of this.

Project fast-tracking would almost certainly require additional capital or for capital to be brought forward, the cost of this would have to be balanced against the benefit to the client in having the project completed ahead of the program.

Fast-tracking introduces new risks that need to be evaluated prior to and during the fast-tracking exercise. From the interviews the risks identified as the most prominent was the potential for increased cost, reduction in quality, less efficient use of materials, less efficient allocation of resources and the swamping/saturation of human resources.

In addition to this it was identified that there could be design input information risks, incomplete information, inadequate consultation in the client structures, future plant aspects not being incorporated in the design; thus there would be the contingent cost of redesign and rework.

According to the interviewees, there is the ever present safety risk resulting from the over allocation of execution resources.

Early revenues can be obtained by a few means; by making permanent plant available to the sinking contractor for the completion of the remaining scope, by seeking early revenues through the commissioning sections of the permanent plant and making plant or facilities available to the operations personnel on the mine.

The early revenues can be either incorporated in the initial design of the plant, for example making an overland conveyor system available for existing plant operations prior to the completion of the new plant, or can be an in execution optimisation.

The plant expansion project could be modular, such as a power station where the six units are designed with the early completion of the common plant to ensure the units are available as they are commissioned.

The planning should therefore identify and provide for fast-tracking opportunities and early revenues.

Fast-tracking should be applied to every aspect of the project, this will present to the client opportunities to take the risk out of the project schedule.

7.19 Large multidiscipline mining (LMM) projects

7.19.1 Large multidiscipline mining (LMM) projects - introduction

Large multidiscipline mining projects have long duration, and high cost with complexity in configuration. With the increasing demands being placed on the EPCM Company architecture
there is a greater emphasis being placed on the ability of the EPCM Company to assist the Client in achieving the goals of the LMM project to assure improvement in the business of the Client.

The large multidiscipline mining project definition has the following general characteristics; the high capital cost, long duration and program urgency, technologically and logistically demanding, multidiscipline inputs from many organisations, and the creation of a ‘virtual collaborative temporary enterprise’ for the execution of the project.

Interestingly the project execution team is trending towards the virtual enterprise, or the collaboration of organisations as a temporary organisation for the purpose of delivering the project. This organisation would dissolve on completion of the project unless there is a contract in place for the operation of the plant until hand over at full capacity to the client.

There is also a trend in place for the large multidiscipline mining project environment for the passing of more risk onto the contractor, more reliance on technical input from the specialist contractor, a risk and reward balance shifting and out sourcing of non-core activities.

**7.19.2 Large multidiscipline mining (LMM) projects - recommendations**

From the interviews there was a general appreciation that the LMM project had cost, duration and complexity aspects:

- Cost would be projects in excess of ZAR1 billion.
- Duration would be in excess of 3 years.
- Complexity would be for projects with surface and underground aspects and in one case including a metallurgical processing plant.

In general, the interviews reflected on the current reduction in appetite for LMM type projects from a capital availability point of view, the remoteness of the ore bodies and from the need to obtain quicker returns on capital investments to satisfy the project financers.

In addition to the above the interviews revealed a growing reluctance on the part of some clients to place an order for the EPCM Company activities with one company. Coupled with this there is a trend to conduct some of the EPCM Company activities with resources from the mining company and tender out specific engineering tasks or packages, the mining company client would then manage the whole project using internal resources and use contracted in teams to supplement own resources as required.

From the interviews came the point that the EPCM Company should be in the position to continuously evaluate the value of the project to the Client particularly where there are scope and schedule changes. As seen above the EPCM Company should be optimising the project, looking for opportunities within the project for early returns and reduced capital expenditure.

LMM projects often have a large number of deliverables, but in general the LMM project would not present any unfamiliar challenges to the EPCM Company operating in the virtual environment.
It was thought by the interviewees that the future delivery of the LMM Project for the EPCM Company is in the virtual environment and that this would require new procedures and improved practices. The client would expect to receive a material benefit from engaging an EPCM Company; this for the client would have to be in terms of time, cost and quality.

As discussed above one of the big new trends identified in the LMM project arena was the trend towards the ‘owner managed integrated team’ this was the temporary owner based organisation established by the owner for the execution of the project.

Some of the interviewees thought that the ‘Junior Miner’ would always be looking towards the EPCM Company for assistance in the execution of LMM type projects. The organisational structures of the ‘Junior Miner’ or the smaller mining company would not support the requirements for staffing a large multidiscipline mining project.

7.20 Project safeguards

7.20.1 Project safeguards – introduction

Project safeguards can be seen as the introduction into the project design and thus in the completed project future options, and also to embed in the process of project site execution options for early returns and early completion strategies.

These project safeguard characteristics increase the value of the project to the Client and are an area where the EPCM Company can add significant value to the business case of the project to the benefit of the Client.

Examples in the large multidiscipline mining project can be for lower cost future plant expansions, allowing for increased production options in existing plant, building in low cost surplus capacity, phased development, and future use of surface facilities beyond the mining operations.

7.20.2 Project safeguards – recommendations

Though, most certainly practised in many projects there was little understanding of the term ‘project safeguard’ from the interviews, this could become one of the significant trends in the large multidiscipline mining project.

The client would want to see the embedded opportunities or project safeguards in the project that can gain the client early wins and reduced net capital out flows in the project.

There could possibly be two sources of project safeguards, from the client and from the EPCM Company. The client would be looking for early returns on capital and the EPCM Company would be hoping for a less taxing project delivery.

The requirement for project safeguards was not clearly understood in the interviews conducted. The opportunities for layers of success and value within and beyond the project were not seen in the responses to this question.
The project safeguard should be a pre-planned and thus embedded benefit or value in the project to safeguard the project for the Client. The result of this would be that the EPCM Company could be assured of continued project activity and possible consequential business.

The intent of the project safeguard is for the introspective safeguarding of the project for the benefit of the value of the project and thus primarily for the benefit of the Client. The EPCM Company would have the benefit of the continuation of the project and the enhanced image of the EPCM Company. The increased resilience of the project to external risks would improve the prospects for the project to be continued and ultimately to be of benefit to the Client.

Not understanding the principles of the ‘project safeguard’ lead to the inaccuracies in identifying examples of project safeguards. Project safeguards are items that create value prior to the project initiation, create value during the project execution and leave a legacy of value after the project has been decommissioned.

7.21 Estimating and bias

7.21.1 Estimating and bias - introduction

Estimating for the large multidiscipline mining project is not an aspect that should be viewed as being less significant than the procurement activities for the project in execution. The estimating for the project establishes the budget for the project against the project time line.

Poor estimating can thus create a significant bias in the estimating of the project costs that can be a challenging position for the project execution team to recover from. Significant overestimating of the project can delay the approval of the project or render the project non-viable.

The complexity and scale of the project creates a significant challenge for the estimating team, the estimating management have to be in a position to establish and prepare the estimating team and organise the tasks to be performed. Often in the estimating phase of the project the package scopes are not clearly defined and some of the aspects of the project will still be in the conceptual phase. This is obviously where the experience of the EPCM Company and the lessons learnt and knowledge management data bases can be applied to the benefit of the estimating team.

A skilled, experienced and versatile estimating team needs to be established with adequate staff numbers for the activities to be undertaken.

EPCM Companies asking for estimates for large projects can affect the market and prices can rise in anticipation of demand, vendors can become complacent when asked repeatedly for complex, detailed pricing and repeated validations. The saturation of local markets can result in planning for the importing of materials which come with specific import premiums.

Large projects have long lists of items for pricing which can result in logistical challenges for the engineering and estimating staff. It is thus important to understand the challenges in managing
the estimating process and obtaining realistic costing for the validity of the project decision making processes.

The estimating process can often result in a bias resulting from the processes used. Recent studies have indicated both deliberate biases and procedural errors in the estimating processes; there is considerable pressure in the feasibility phase of the project to ensure the project goes into execution. Estimating errors identified in literature review indicate that inflation corrected errors are causing project to exceed budgets by an average of 14% and sometimes by much more.

To give an improved assurance of project success the EPCM Company should apply sufficient controls in the estimating process and apply learning from previous projects to ensure the estimates are as realistic as possible to allow the client to make reasonable decisions as to the efficacy of the project to be executed.

7.21.2 Estimating and bias - recommendations

There was general consensus as to the significant challenges presented by estimating for the LMM project or ‘mega project’.

First there is the client definition of the project and the creation of the input data for the project team to be able to arrive at a representative scope for the project; inaccurate input data will compromise the accuracy of the estimates.

Next there was the complexity of the EPCM Company project definition and arriving at suitable framework of packages and designs for the vendors to price with confidence, the engineering and estimating team can become overtasked particularly with rigid and challenging timeframes. In addition, there could be a few EPCM Companies working on the same project or similar projects and this would lead to ‘vendor fatigue’, the reluctance on the part of vendors to give too much effort to providing well thought-out tenders.

Successful estimating starts with an accurately defined scope of work for the project and a detailed package list. The greater the accuracy of these fundamental project documents the greater the accuracy of the tender documents that will be provided to the estimators for the estimating process. According to the interviewees time spent here will improve the accuracy of and confidence in the estimates received.

The resources and time available for the estimating process must be sufficient and have the skills required for the process. The EPCM Company should have a good database of current and running projects against which they can benchmark the project in the estimating phase. This will also give the estimators the opportunity for peer reviews by persons working on current projects.

When the market is saturated with projects in the bankable feasibility study (BFS) and definitive feasibility study (DFS), phase then a certain amount of vendor fatigue can be expected. The vendors, according to the interviewees, would review the requests and arbitrarily prioritise these for action, placing some at the bottom of the pile as being the least likely to convert into ‘projects
in execution’. This results in the accuracy of the tender being reduced and thus affecting the accuracy of the final CBE document.

According to the interviewees a spread of projects with the EPCM Company would produce a good database of costing material. The EPCM Company that has a good database of recent projects and studies would use this information to generate more realistic estimates.

The responses from the vendors could reflect the workloads in their workshops and the perceived success of the EPCM Company in converting CBE and feasibility studies into execution projects. In times of reduced workload and future optimism, good responses could be expected, and EPCM Companies that are perceived to be more successful and have a good client base would receive preferential responses.

Bias and error in the estimating process can be deliberate or unwitting. The vendors would price to the information available and make assumptions that may be inaccurate. The risk and uncertainty factors would be reflected in the perceived accuracy of the tendering documents.

The vendors may be pricing on many quotes certain that there would be little opportunity for this to become an order, as such little effort would be expended on pricing accurately and realistically. The time required to produce these estimates is normally compressed and as such the estimates would be based on heuristics. The project team would be keen to sell the project based on lowest costs and best returns.

Cost overruns have a negative effect on the project value. Attempts to remain within budget will result in scope cuts and pressure on the execution team to bring the project in earlier:

- There will be increased client scrutiny on the project execution team,
- Additional funding would come at a premium,
- The business case for the project may be compromised,
- The project may be delayed to normalise or reduce the cash flow,
- Other projects in the pipeline may be delayed or cancelled.

With the smaller less experienced mining company or ‘Junior Miner’ in particular there is greater competition for project funding. This is less so with the bigger mining companies where there is a perceived better security for the investor.

In addition to the underestimating bias according to the interviewees, the project often goes forward with an unclear and incomplete scope, and an optimistic execution plan. These aspects would often result in a lower budget for the project not from underestimation, but from an incomplete scope being presented for costing. According to the interviewees, the reduced project costing presents the best NPV and IRR for the project.

From the interviews there is a general desire for the project to proceed into execution and to support this there was an entrenched desire to reduce the estimated cost of the project. This would be to secure the financing for the project in competition with other projects. Linked to this is the
‘best price’ approach to the estimates received from the vendors, this was to ensure the vendor is placed or remains on the approved vendor list.

Although the term ‘asymmetric information’ was not understood by all involved in the project execution, it was interpreted as the selective presentation of information, which is indeed what it is. Asymmetry of information is a practice used to support or not support the execution of the project this can occur at any time in the project execution process and affect any aspect of the project. The sources of biases were listed by the respondents in the case studies. The sources were clearly understood; of the responses received the following could be considered to be the sources of biases:

- Personnel arrogance,
- Project discussions being directed by people overinvested in the project,
- Group-think situations going unchallenged,
- Failing to review all data, reviewing only recent data,
- Selective opinions,
- Unsupported confidence,
- Stubbornness,
- Not using lessons learnt and past experiences.

Asymmetry of information should be intercepted by the parties carrying out the project peer reviews, asymmetry of information would be, from interpretation of the interviews, less prevalent in mining companies that have a significant experience in project execution.

Understanding the estimating processes and the complexity associated with larger project it could be assumed that the smaller project would be easier to define and thus less complex and demanding on the resources assigned to the estimation processes. The controls can be applied at the front end of the process by allowing time for this process to be executed and prior to this ensuring the items for costing are as representative as possible. Time needs to be provided for the development of the scope and the supporting component listing.

Another control process proposed in literature reviewed was a process of cognisant weighting, understanding that there is often a budget overrun of 14% then this could be used as the project cost weighting or provided as a project contingency. In execution there should be a careful cost control process employed to ensure the budgets are adhered to and the objective of the scope is maintained.

All of the respondents to the interview process saw that there was a significant bias on project returns in favour of the project. The returns are often based on optimal site conditions and best case practices. It is in the interest of the persons assembling the project feasibility study to see the project proceed and to support this the project pay back is optimised in favour of the project. According to some interviewed the project returns are often based on inadequate or optimistic ore body valuations, costs can be cut during the exploration phase of the project and the results
obtained from the valuations can be inadequate. The exploration phase should be reinforced to ensure the ore body is fully understood and the interpretations of data obtained are valid.

In general, the interviewees thought that project risks are downplayed and misrepresented. This can either be cognizant or coincidental, the risk review process is by its nature subjective and biased by the opinions of the people or the groups taking part in this process. In the baseline risk assessments personal biases can come to the fore and there would be a desire on the part of the team performing this activity to see the project proceed. Estimates are often optimised by lowest costs and incomplete scopes.

7.22 Forethought

7.22.1 Forethought - introduction

Forethought is a critical process in the establishment of the project, the development and socialising of the project team and the grounding of the project team working environment.

From the literature forethought is thought of as conducting a project pre-mortem, as a standalone activity away from the project development process. The forethought approach is designed to identify the significant project biases and to identify and if necessary quarantine the people in the project team that have exercised too much influence in the project feasibility studies. The forethought processes allow for the questioning of the fundamental project principles.

7.22.2 Forethought - recommendations

Forethought was identified by most of the interviewees that open discussions in the CBE phase of the project are taking place. There was some doubt as to the overall effectiveness of these discussions. There was also some doubt as to the effectiveness of the client input into these discussions.

Like any such open discussion the meeting has to be well managed to ensure everyone has a chance to provide input into these discussions and that the discussions are not focussed on to one person’s opinion.

In the case studies it was clear that not all of the persons understood this concept. The ‘over-invested’ person can be in a position that directs the project team’s perceptions and efforts with respect to the project and the project completion.

The ‘over-invested’ person, dependent on their level of influence, could be a significant source of biased information and this could be detrimental to the ultimate project execution.

The bias of information is preferably addressed with the individual, or when the influence of this person can be used in the best interest of the project.

From the interviews it was identified that there are several tools that are standard in project execution. There were the tools of HAZOPS and, risk and constructability reviews. The careful
application of these tools would give the project team the best opportunity to identify potential project failings. In addition to this would be the application of well managed ‘project pre-mortems’. With a good lesson’s learnt library the ‘project in execution’ can compare elements of the project against the documented understanding of the EPCM Company. In addition to the standard tools, the project execution team can review the actions taken on other projects and use this as a basis of design.

7.23 Project risk

7.23.1 Project risk – introduction

There is a substantial quantity of literature devoted to the subject of hazard identification, risk appreciation, quantification and mitigation.

Projects being one time undertakings are subject to uncertainty and thus subject to risk. In managing these risks the project should provide adequate buffers in the activities and durations to absorb or mitigate the risks.

The project team should ensure the risks identified cover both the external business risks as well as the internal operational risks. The risks are evaluated at both the project level in the feasibility analysis and at work package level during implementation.

The human interface with project risk analysis should not be disregarded, studies have shown that some high risk issues that later prove to be the project’s downfall can be disregarded at the outset of the project. Project teams can collectively become complacent.

Should the risks be managed by the client, by the contractor or shared?

A text reviewed indicated that certain risks are best owned by the client such as:

- Poor buildability,
- Omissions in the tender document,
- Changes in the work scope.

Other risks are best managed by the contractor:

- Availability of labour
- Poor subcontractor selection
- Poor quality workmanship

Other risks can be shared:

- Unexpected inflation levels,
- Force Majeure,
- Changes in government regulations.

Naturally the client would wish to transfer the project risks onto the EPCM Company and the contractor would want to transfer the implementation risks onto the client.
The articles on risk reviewed refresh the risk analysis process in so far as risk identification, risk estimation followed by risk analysis and evaluation. This is elaborated by the newer technology risks where the risks associated with the implementation of new technology in a project is evaluated along with the actions taken to ensure this technology is accepted by the client and the operating personnel, ‘how can the resistance to change be mitigated?’.

The literature discussing the running of large multidiscipline mining projects in developing countries finds some of the principle risks to be the securing, retention and cost of assembling the necessary skilled and experienced resources by the developer.

Further the same author states that many projects uncover risks that were not foreseen during the initial risk assessments, the principle failing was that the risk assessment processes being used relied heavily on evidence from previous projects. Large multidiscipline mining projects are complex and unique undertakings that would not compare with established project risk assessments. Some authors are promoting agile risk management where the risk is allowed to manifest prior to action being taken. The pre-compiled risk management plan would be a secondary document; the primary function of the project manager would be to monitor the project process related risks as they develop.

As discussed elsewhere the large multidiscipline mining project can be viewed as being a portfolio of projects. This would present an additional set of risks to the project manager. The management of a portfolio of projects generates a new set of challenges particularly regarding the interaction between the differing projects, and the complexity in managing diverse groups of stakeholders.

The literature intimates that the current risk management techniques are only suitable for the single project environment and would rely on the expertise of the project manager to evaluate the interaction risks between two or more projects. In the same discussion there is acknowledgement of the intuitive approach to risk management, experienced managers and project directors can apply intuitive risk management metrics to manage risks and opportunities.

Where the risk management process has to be applied to a portfolio of projects then the following steps would be applied.

- Analysis of project issues between projects,
- Analysis of one project issues with all the projects risk data,
- Compare the risk data from different projects.

This is not a simple process but it gives the advantage of rolling risk analyses forward from project to project and gives an increase in the learning of the company particularly where project risks are concerned. The mitigation techniques for identified risks can be of benefit to projects earlier in the project life cycle.

A large multidiscipline mining project, at the peak of activity can have many contractors and subcontractors working at the same time on one site. This can introduce new risks to the managing contractor or the EPCM Company. Much of this risk would be in the dissemination of information
between the contractor and the sub-contractor. Information security has to be paramount but can be difficult to manage.

Are all risks managed, or are some risks allowed to manifest and then be managed. There are articles that intimate that some risks are not acknowledged and are left to manifest themselves during project execution. The project manager’s responsibility is to deliver the project to scope, budget and on time, the identified risk could be perceived as preventing the project manager from delivering the project and left unaddressed. The risk mitigation may be delayed and the risks dealt with on a come what may manner.

Large multidiscipline mining projects are often subject to pressure from the client to speed up delivery and reduce cost. There is an early commitment to foundation conceptual aspects of the project to speed up delivery with a risk that there could be substantial rework in the downstream implementation phase.

Some literature reviewed intimated that moderate design postponement would not delay the project beyond the expected delivery date but would reduce the risk of design rework. There would have to be a detailed review of the project uncertainty prior to committing to an early design freeze. Authors have highlighted an endemic problem regarding risk management, the problems associated with a lack of entrenchment of risk management practices. Even though there is a big array of risk management tools and techniques there is a general reluctance to fully adopt these tools and techniques. This could be associated to a lack of awareness and over confidence, or as intimated earlier, an approach to managing the risks as they arise.

Expediting project delivery often requires the EPCM Company to run project aspects concurrently, relying on project team experience to manage the interfaces and uncertainties between the interdependent activities. With changes in technology, environment, market demands and competition there is more pressure being placed on the company processes. Concurrent engineering is thus becoming more risky.

As a tool to assist in the management and grouping of risks one author in the literature reviewed proposed the utilisation of the ‘risk breakdown structure’ or RBS, the RBS is a tool to present the risks in a structured format to aid comprehension.

The RBS groups the risks according to the sources and categories and so on to enable a clearer view of the risks to facilitate the efficient management of the risks. The risks ‘hot spots’ and key risk insights are displayed using this technique.

Despite the focus on risk management and the application of time resources to this activity projects still fail to meet their objectives in terms of time, cost, quality and performance.

This according to authors’ uncertainty risk results from the prevalence of unknown unknowns or the items we have ‘not bothered to find out’.

According to the authors these unknown unknowns reside in domains or subsystems:
• Result subsystem,
• Process subsystem,
• Organisation subsystem,
• Tools subsystem,
• Goals subsystem.

In addition to the above there is a churn of uncertainty driven by the following aspects:

• Complexity,
• Complicatedness,
• Dynamism,
• Equivocality,
• Mindlessness,
• Project pathologies.

The authors propose a process to convert the knowable unknown unknowns into known unknowns. This involves the application of a series of techniques that will generate an environment of risk alertness, an environment where unknown risks can be detected and elevated to a point where they can be effectively managed.

7.23.2 Project risk – recommendations

Project risk has been a specific topic of interest with regard to project management since the mid 1960’s.

The interviewees defined risk in a similar manner; as the chance that an event could occur that would lead to a loss, damage or an injury. It should be noted however that there are two areas where risk will manifest; the project physical environment risks and the human activity risks. Projects being one off activities are subject to uncertainty and as such are subject to risk where the activities on the project may not elicit the desired outcomes.

The interviewees saw both generic risks and specific risks that were relevant to their project environment. The generic risks could be grouped into the two principle risk sources whereas the specific risks were all associated with human action.

The interviewees, as expected had the same standard approach to the risk management process:

• Document the risk assessment process,
• Identify the risk,
• Determine the probability of the risk occurring,
• Estimate the severity of the risk should it occur,
• Evaluate the risk to determine if corrective action is required,
• Develop a strategy to mitigate the risk if this is required,
• Measure the effectiveness of the mitigation through re-evaluation.
Effective risk management, according to some interviewees also requires the regular review of the evolving project risks and the monitoring of the effectiveness of the risk mitigation activities and adjusting actions as necessary.

From the Client group interview came the feedback adding the; identification, analysis and response to risk factors throughout the life of the project, increasing the effect of positive events and reducing the effect of negative events.

The EPCM company point of view the sources of the main project risks were identified thus:

- Significant scope changes,
- Main contractor performance,
- Skills migration and shortage in all aspects,
- Installed plant not performing to the final design,
- Capital rescheduling,
- Client and EPCM Company relationship,
- Exposure to poor safety performance.

The contextual case studies reviewed indicate that complexity and uncertainty, challenging International aspects, project execution delays and capital scheduling would be sources of significant risks from the project execution standpoint.

These risks should be addressed with appropriate action as determined by the risk assessment processes.

The timing of the action should be appropriate to the time the risk is expected to manifest itself especially where the action requires the allocation of resources and incurs cost. The interviewees stated that the risk assessment process should be continuous and thorough particularly where there is a change of activity or a change in the main contractor.

Risk management covers many if not all of the aspects of managing a large multidiscipline mining project; not least of these is the design activities of the project team and the assembly and socialising of this team into a coherent working group of people.

As seen above, team formation in the EPCM Company environment is limited by the scarcity and availability of resources and the necessity to get the required resources released from other commitments within the company. From the client group interview there was a reluctance to work on the project in execution and the challenges with personnel not understanding the risks associated with the project.

Interviewees examined the following team risk sources:

- Identifying the correct resources,
- Identifying the correct number of resources,
- Having these resources required at the right time, released from other commitments,
- Team induction into the project processes,
• Getting the people to work together effectively, building effective teams.

The team risks that should be considered includes the cultural aspects, technical challenges, social, political, legal, health, economic, managerial financial aspects of the project. All of the aspects of the project where the people working on the project can affect the project outcome should be considered human risks.

The interviewees saw the main human risk associated with the project in execution was the loss of an essential and integrated resource at a critical time in the project life cycle.

In the International project environment these risks should be appraised with the International partners and the International points of contact examined in detail.

From the literature in an article on project risk management there was a reflection on the managing project risks as knowledge gaps. Knowledge gaps are defined in the literature as the gap between what we should know in order to succeed and what we really know, the knowledge gaps can be applied to technology aspects as well as logistical gaps. Projects being once off undertaking, risk assessments are in effect the proactive management aspects of project management. Risk mitigation through the management of knowledge gaps can be seen as managing the uncertainty in the project.

From the interviews knowledge gaps have to be identified as soon as possible and bridged either with training and mentoring or through the selective recruitment of additional resources. The EPCM Company could also draw into the project team selected external experts for the duration of that phase in the project. There is also the option of seconding to the project specialist vendors. Should the knowledge gap be in the form of a lack of understanding of plant characteristics then additional testing can be carried out or additional feasibility studies?

Of course knowledge gaps can be addressed by either increasing the knowledge of the technology or by moving the technology application into the known and established technology field.

In considering 'operational risks' the interviewees focussed on the day to day operational risks incurred during project execution. Examples cited included losing a skilled team member or a critical component or service not being available when required.

The literature refers to the 'business' risks and 'operational' risks when dealing with large multidiscipline mining projects. In this context the operational risk refers to the mechanisms of the project execution and delivery such as; project leadership, contractors, suppliers, technical complexity and so on. It is suggested that a hierarchical approach is followed from; project to package to individual activity.

All of the interviewees suggested that they evaluated the business risks as well as the operational risks. This has to be viewed in light of the understanding of the terms; ‘business risk' versus 'operational risk'. In the EPCM environment, according to the interviewees there are two risk evaluations; the client to EPCM environment risk assessment and the project based risk...
assessment. Reasonably only the project based risk assessments are shared with the Client. The Client embedded EPCM group interview reflected on the enthusiastic Client risk assessment processes and risk evaluations that cover such items as money, time, reputation, legal and safety. Clearly the ‘operational’ risks need to be enhanced in the EPCM Company risk assessment processes.

Generally, however internal and external risks are evaluated in the risk analysis process the internal project risks would be of particular interest to the EPCM Company whilst the external risks would be of particular interest to the Client. The risk assessment processes followed should be as all-encompassing as possible.

Risk analysis should be conducted at all stages of the project; project development, project selection and project execution. From the interview transcripts the following process was identified and developed:

- Identify all of the possible project risks,
- Assess the risks,
- Ranking of the risks to identify those to be addressed by priority,
- Evaluation of the risks to identify the most suitable point in the execution to address and mitigate the risk,
- Develop a contingency plan,
- Review the progress and effect of the risk mitigation technique that has been applied, re-rate the risk after mitigation.

From the EPCM Company point of view there should be; project risk assessments, EPCM portfolio risk assessments, Client risk assessments and EPCM Company risk assessments. All of the interviewees stated that all risks cannot be identified in the initial risk management process. Items identified during the risk assessment processes are only those items apparent to the people carrying out the risk assessment. It is therefore incumbent on the project execution team to re-evaluate the risks and identify new risks exposed during the project execution. New work packages will come into execution and the project team risk experience will be expanded.

Therefore, the risk assessment process should be continuous and certainly carried out when new work areas are being opened, new activities are being undertaken and for each package as the package moves into the design phase and into procurement or execution.

The interviewees were asked to identify the five main sources of risk resident in their projects. The aggregate main project risk sources are listed below:

- Main contractor poor performance: 4 occurrences,
- Lack of capital availability: 3 occurrences,
- Engineering design oversight: 3 occurrences,
- Significant changes in scope from the client: 2 occurrences,
• Significant program delays: 2 occurrences,
• Project procurement delays: 2 occurrences,
• Mine licensing delays: 2 occurrences,
• Significant safety incidents – fatalities carry legal accountability: 2 occurrences.

From the EPCM interviewees’ point of view the biggest source of generic risks was the client this was followed closely by the risk presented by main contractors. Following this was the project external environment and the internal risks presented by the EPCM Company.

As could be expected the interviewees agreed that communication is the key to effective risk management. Everyone should know what the risks on the project are, if not the detail of the risk. In addition to communicating the project risks the mitigating actions should also be communicated.

Communication can also become the source of risk; communication management is covered elsewhere in this document but it should be said here that communication risk is the ability to transmit information effectively within the project. In the International workplace communication management needs to be sensitive to the time, language and cultural hurdles.

The two main responses to the question about the principle risks were the assured capital availability and the project cost overruns. Schedule overruns and scope changes headed the remaining concerns from the interviewees.

There was a general consensus from the interviews that the risk management processes would have to be modified to fully reflect the requirements and challenges of the large multidiscipline mining projects. In general, the process would have to be streamlined to make it more accessible and more easily to access. One of the authors stated that there is a threat to the whole risk management process that it gets ignored and risks go unrecorded unnoticed. This would lead, as the literature states to project failure coming as a surprise at the end of the project.

For large multidiscipline mining projects there is a necessity for, proactive risk planning as well as reactive risk appreciation and management. This was reflected by the interviewees where there was a stated need to be proactive to allow for planning of the responses to the known risks and to be able to respond to risks as they become apparent. According to one interviewee there was a certain place for a reactive approach to risk management particularly in a fast moving and rapidly evolving project environment. The proactive approach allows for the pre-emptive identification of the risks allowing for the preparation of contingency plans. However, as we have seen elsewhere not all of the risks can be identified in the risk assessment process and the unseen risks would require a reactive or inventive management process to be implemented.

As stated there is a trend towards bigger projects, greater technical complexity, International resourcing, and multi project clustering. All of these aspects add to the complexity of the individual project. The Client or end user is trying to get more out of the project execution to improve the returns on the project.
In managing a portfolio of complex projects the new principle risk would be ascribed to the additional complexity of the diverse project tasks to hand. The portfolio risk would be more significant should the project be for different clients or be in differing business sectors. The portfolio of projects would also introduce time and priority management challenges and the management team being exposed to multiple project liabilities.

There could be a reduced individual project focus possibly causing some of the project details to be missed and emerging risks not to be picked up in good time. There could however be benefits accruing from running a portfolio of projects with the understanding of risks on one project giving insight on another project.

Though most of the interviewees were confident that the current risk management processes were suitable for the management of a project portfolio some indicated that the process would have to be enhanced and one indicated that the inter-project risks would have to be considered.

One interviewee was adamant that the current risk management processes are not suited to managing the risks attributable to a broader portfolio of projects. The risk assessment processes, according to one interviewee should be extended to the project manager, to evaluate the management risk associated with managing multiple projects.

The management of a project portfolio requires analysis of the inter-project risks; the next step would be to analyse each project with the risk data from the other projects. Finally, the risk data from all of the projects is compared in a single analysis.

Obviously where all of the projects are for the same client there will be a substantial amount of commonality between the risk assessments. By following this process there will be advantages in the identification of common risk areas, cross project feedback and learning, organisation benefits where common risk areas are identified leading to improvement projects for the company.

Interviewees saw the risk management process as being primarily intuitive as it is based on the experiences of the contributors to the risk assessment sessions. The risk assessment process however has to be open and well managed as it is essential that all risks are considered. The intuitive risk management process is always front of mind with experienced project organisation and is adopted by most experienced people when dealing with the wider perspective of the project based organisation.

In the execution of any mining project there is always an opportunity for new risks to be introduced by sub-contractors brought in to the project to execute a particular scope of work. The sub-contractor will often not understand the evolving history of the project and the operating environment of the project. The new risks introduced by the sub-contractor would include relational risks and the additional communication channels adding to the complexity for the EPCM Company. The sub-contractor would not understand the communication protocols and the information hierarchies present on the site. One of the interviewees stated that the sub-contractor would introduce specific risks of knowledge, competence, management, skill, values and culture.
All of the interviewees agreed that all of the risks are manageable though not all risks would need to be managed in the execution of the project. In reality all risks can be managed even if this implies that the risks will be monitored during the execution of the project for any change in the propensity for an impact on the project. Some of the risks identified would of course require no mitigating action.

It was noted in some of the interview reports reviewed that risk management is an ongoing effort and requires regular review with the same team or with additional team members. The team executing of the review process would have the advantage of project execution experience and would be able to review the project in the changed project execution environment.

The categorisation of risks can be done in many ways to suit the requirements and priorities of the project, project management team and project reporting.

The most popular categorisation from the interviewees was:

- Plant area,
- Perceived occurrence,
- Scale of effect or severity,
- Cost of risk event,
- Risk custodian,
- WBS.

There was general consensus amongst the interviewees that risks cannot be ignored but some of the risks would be recorded and simply monitored for a variety of reasons; low risk, low impact, low cost, low possibility of occurrence or not falling into the project execution period.

Risks would have to be monitored during the risk review sessions to establish if the risk rating has changed in the intervening period. From the literature review risks would have to be carefully reviewed by peers to ensure they are not being ignored through complacency on the part of the project execution team.

According to the interviewees there was a confidence that the main risks would have been identified but they understood that some of the project risks would only be exposed during the execution of the project. Unique risks would be linked to the different phases of the project. A certain number of risk scenarios can be carried forward from lessons learnt on previous projects but due to the unique nature of projects there will be certain risks associated with the project.

In large multidiscipline mining projects there often has to be an early commitment to certain aspects of the plant design. There is also a benefit for the EPCM Company from doing this in that the design and drafting office can be more effectively utilised.

From the client aspect there is a trend that the operational personnel would like to keep the design options open for as long as possible this will allow developing operational requirements to be incorporated in the final project consideration.
It is the nature of the mining industry that there will always be an element of change in the design requirements. Safety is a significant consideration in mining operations and this can change plant configurations particularly with regard to energy management and transmission.

There will always be encouragement for the Client to commit to an early plant configuration to allow the design and drawing office to continue with detail design. There is always a risk that the client will want to open more options and request additional trade-off studies.

As a counter argument design postponement is a strategy that can be linked to optimisation of the workload on the engineering design and drafting office. With design postponement it can be better assured that the design input information is as comprehensive as possible, current plant considerations can be incorporated and design rework is minimised.

Design postponement, as with design expediting also gives the EPCM Company the opportunity to practise load balancing on the design resources of the company particularly where the design resources are scarce and have to be used on several projects.

For the execution of the large multidiscipline mining project there is often a requirement for excavations to be dimensioned for the mining to take place and this is often far in advance of the equipment to be procured for installation. Equipment may be required for the shaft sinking operations as well as permanent duty; this would require an early commitment for the design or sizing of the permanent plant.

Certain aspects of the project may be brought forward in the program requiring design aspects to be expedited; but this could be present in any execution program.

The client would generally be of the opinion that expediting the design process would result in a cost saving. In addition, there would be the understanding that the early design activity would create project float and facilitate early work on other design aspects. With a design float there is an opportunity for the client to become more involved in the design process, multiple iterations of the design process will naturally incur costs and could demoralise the design staff.

With design and drafting packages complete the client has the option to procure plant earlier and possibly benefit from cost or exchange rate savings.

Concurrent engineering is a common practise where the criteria for its application are present and necessary. The application of concurrent engineering has to be necessary, the input information has to be complete, the resources have to be available and the design teams that are required to work in the same plant area have to be coordinated.

The application of concurrent engineering has to be risk assessed and the budget required for this activity has to be available and agreed. The client must also agree that the design and drawings outputs need to be reviewed and approved in line with the engineering program.

As discussed in the interviews from the client perspective there is clearly a bias from the EPCM Company to encourage the project to proceed, the EPCM Company wants to bill hours to earn
revenue whereas the Client wants to grow and improve the business of the company from the project implementation.

An EPCM Company interviewee indicated the following points of potential conflict:

- Communication,
- Goals and direction,
- Differences in opinion,
- Differences in strategy,
- Understanding.

Clearly there should be a significant effort to ensure the Client and EPCM Company processes are aligned to ensure the priorities and technical solutions are reflected in the technical solutions.

When there is a necessity to compress timeframes with concurrent engineering it was understood that there were new risks introduced. There was an increased risk of rework should designs prove to be inadequate. There is also a need to coordinate the resources working on different aspects of the design.

For the EPCM Company there was a need for clear, concise and agreed design input data and access to a suitable and adequate resource to manage the workload increase.

With the EPCM Company moving into the Global environment; either from a project execution or from a project location point of view there is a new set of risks being presented. During the establishment of the project the following should be considered; the coordination effort, the cultural differences, common engineering understanding and the global understanding of the project.

The key aspects to be considered from the execution viewpoint are the establishment of a common understanding, communication and coordination of the efforts. With the global project location comes the logistics, legislation, taxation, procurement standards and bribery risks.

Regarding the implementation of a risk breakdown structure most of the responses had not considered implementing this method of risk grouping suggesting that the current method of risk management was adequate for the risks identified. The risks identified are clear and understood. Should a more complex project be undertaken then the Risk Breakdown Structure could be used. Utilising the risk breakdown structure would however enable a category breakdown of the project risks and this would make the risk trending of the project easier for all participants to understand and contribute to the management process.

There was a possibility however that the current risk management system is too onerous and a more straightforward system for management would encourage more risks to be identified.

The key project risks have to be clearly communicated to all of the participants in the project execution. The diversity of the people involved in the project can have an enriching effect on the project risk assessment process. There was a consensus that this was not the case in the EPCM Company environment.
The wider the involvement in the risk management process then the perception is that the unknown unknowns might be identified and new project risks tabled.

Explaining risks also gives the risk custodian the opportunity to analyse the risks in light of new information and inputs.

7.24 Project sponsorship

7.24.1 Project sponsorship – introduction

The effectiveness of the project sponsor is critical to the long term success of the project and for the long term success of the project sponsor’s company. The roles and responsibilities of the project sponsor should be structured and understood so as to support performance in this critical role.

The project sponsor would be an executive of the company with a vested interest in the success of the project. The project sponsor would be required to; ensure planning, clarify outputs, smooth stakeholder relationships, support the project unequivocally and appoint the project manager.

The effectiveness of the project sponsor would be contingent on the role player having; appropriate seniority, the ability to establish senior connections, willing to take up the project support challenge, ability to partner with the project team, excellent communication skills, the ability to prioritise, the ability to challenge the project and personality to create working relationships with the senior project personnel.

The role of the project sponsor is seen as a point of divergence between the EPCM Company sponsorship outlook and the Client sponsorship responsibilities.

The EPC M Company project sponsor would have the dual responsibility of managing the interface with the client and in the interests of the EPC M Company whereas the Client project sponsor would solely have the business interests of the Client as the primary responsibility.

7.24.2 Project sponsorship – recommendations

From the interviews the project sponsor’s role is to act as the interface between the senior role players in the Client organisation and the senior role players in the EPC M Company.

- The project sponsor ensures the project receives the support required from the board,
- The project sponsor provides the budget for the project,
- The project sponsor embeds the project in the company structures ensuring there is a fit between the project and the needs or structures of the company,
- The project sponsor will appoint the senior team members for the project studies or the project execution,
- The project sponsor is required to maintain an overview of the project in execution ensuring the project remains on track,
• When required, the project sponsor will directly or indirectly guide the project team and provide insight where required from a business perspective,
• The project sponsor needs to be an excellent communicator with appropriate seniority within the company,
• The project sponsor needs to have the contacts within the company and good networking outside the company in particular with the client group,
• With appropriate experience the project sponsor must be able to maintain a balanced view of the project with a big picture view of the business requirements and strategic direction,
• The project sponsor needs to be proactive and yet remain in the background.

According to the interviews the EPCM Company project sponsor needs to look after the needs of the EPCM Company business and at the same time be fair and balanced to the needs of the Client. The EPCM Company project sponsor would out of necessity be the project sponsor for several projects.

The Client project sponsor would be solely looking after the needs of the client. According to interviewee input the Client project sponsor would often be the person who has identified the need for the project and would therefore have a vested interest in seeing the project succeed.

There could be seen to be a conflict of interests between the Client project sponsor and the EPCM Company project sponsor. The EPCM Company wants the project to go ahead to earn revenues for the EPCM Company and the Client wants the project to add value to the business of the Client’s company. The Client project sponsor would therefore tend to be more involved in the day to day activities of the project whereas the EPCM Company project sponsor would tend to be more remote from the day to day project activities.

There are three organisational areas where the project sponsor needs to be active; at the company executive level, at the management level and at a project level.

• The principle level of operation for the project sponsor is at an executive level where the sponsor tracks the project progress and gives feedback to the board, manages the high level interface with the client looking for developing opportunities, and champions the project with the senior management ensuring the project team is supported with the necessary resources,
• From a management point of view, the project sponsor acts as a high level mentor for the project team,
• From a project level the project sponsor holds the project in context and provides direction and offers challenges where required.

These actions have to be completed without the project sponsor becoming involved in the day to day activities on the project. The project management team appointed by the project sponsor should be left to manage the project and carry out the day to day activities on the project. Over
involvement by the project sponsor would disempower the project team and thus render them ineffective.

The EPCM Company project sponsor must set as the primary goals for the project; Client satisfaction with the project progress and on completion of the project, the goals for the EPCM Company being achieved (profitability, retained learning and enhanced reputation), and the project completed within the project execution criteria.

The project sponsor must be available for consultation when required and display good leadership characteristics.

In the EPCM Company environment it is easy for the project sponsor to become overcommitted to activities such as business development and to become overinvolved in other projects. In doing so the project sponsor cannot track the relevant developing issues on the project. Also the project sponsor can become too involved or over committed to other company duties and cannot give the time necessary to act as the project sponsor.

The project sponsor must be up to date with the issues on the project and be able to choose the optimum time to become involved in the project. The project sponsor should call meetings with the senior project execution teams when required. The project sponsor needs to create the environment for project success.

The project sponsor can fail to give the necessary high level interaction with the client senior management or become too client orientated.

Where the project sponsorship is perceived to be inadequate and ineffective then the project sponsor would in general be bypassed.

In other interview responses the project manager would elicit interaction with the project sponsor directly and bring the project sponsor into the project activities directly.

From the Client group there was a different requirement from the project sponsor and the project manager would go to the extent of having an agreement with the project sponsor as to the schedule and time required for interaction with the project. This would include an understanding as to the project issues that the project sponsor would be required to take ownership of and manage.

The principle challenges facing the project sponsor in the EPCM Company environment are the high levels of complexity introduced by dealing with many different clients and volatile projects, credibility, being overtasked and being able to engage with the client on even terms.

From the Client point of view, the project sponsor must be able to champion the company’s vision, goals and expectations without managing the project directly.
7.25 Communication

7.25.1 Communication - introduction

The literature states that effective communication is fundamental to the success of a project. Communication creates stakeholder liaisons that are essential for the coordination of the project and, to guide and coordinate the continuing activities of the project team. The coordination of activities on the large multidiscipline mining project is essential when the interdependency of activities that may be occurring concurrently is considered.

For the EPCM Company working in the International environment communication becomes a bigger consideration as it is necessary to manage a dispersed team often operating in different countries and in different time zones. Coordination of these teams relies on the timely dissemination of information to ensure the teams are properly coordinated; this can be both formal and informal, though formal communication would be used for the coordination of the activities in the dispersed team.

As discussed in the estimating process, with communication comes the challenges presented by biases or asymmetric information, this is generally where one party to the project is better informed than the other. This can create a situation where resources are not deployed efficiently and there is a loss of welfare. Asymmetric information is best managed by full transparency of information and designing the flow of information to suit the needs of the stakeholder group. The stakeholder group can be changed to suit the phase of the project and by its nature include temporary subject matter experts.

Communication must also be used as a means to ensure the client stakeholder group is aware at all times of what is being developed, delivered and at what cost to the project. Effective communication using various media can effectively bridge gaps that may be developing during the project execution.

The stakeholder circle methodology can be used to create the communication matrix for the project; identify and map the stakeholders and their importance, requirements and interests, prioritise, understand the stakeholders’ attitude to the project, monitor the effectiveness of the communication and modify if required. The stakeholder community will change during the execution of the project so this process must be continuously monitored and refined. The process of stakeholder communication and management is partly instinctive and partly based on good practice and experience. It will certainly develop during the execution of the project to suit the project requirements.

7.25.2 Communication – recommendations

Communication is a process to inform and involve personnel, to give instruction and direction, for feedback and to place on record. Communication is also about being visible and engaged with the people working on the project.
Communication is used to align everyone on the project to the project goals and to identify the problems areas where the senior management must focus controlling efforts.

The communication strategy and framework for the project has to be established early on in the project lifecycle and modified as project demands dictate. The interviews revealed consistently; the identification of the stakeholders, the frequency of communication, the form of communication, the items to be communicated, and the identification of the key meetings and the frequency of these meetings.

From the interviews poor communication can result in chaos. Information is used for decision making and poor information can result in poor decisions and thus delays and costs to the project. Annoyance can result from the dissemination of incorrect information resulting from project pressure to correct the resulting decisions.

By inference therefore the efficient running of the project is dependent on the correctness and efficiency of the communication between the project management, project engineering disciplines and procurement.

Clearly not all of the project communication is formal. There is a large volume of informal communication in the project but as was noted from the interviews, project personnel have to understand the protocol boundaries of the informal communication and the point where formal and recorded communication is required. The requirement for content control and the control of distribution of informal communication has to be understood and practised by the personnel working on the project.

Informal communication is acknowledged to be of great value in the project environment. This is the medium of brain storming and the transfer of project learning. Project challenges can be resolved quickly with informal communication though some aspects have to be transferred to the formal environment for control, ratification, costing and capturing. Informal communication is the medium of mentoring and coaching and can build lasting relationships and trust.

The primary responsibility for formal project communication rests with the Project Manager. In the project structures however there are responsibilities for communication channel management resting with the PSO, the Project Liaison Officer, the Document Controller and the Contracts Manager.

One of the interviewees reflected on the problems with people not communicating, so the challenge facing the project is to ensure everyone has the opportunity to communicate and that they do communicate.

As discussed previously, with any communication will come asymmetric information. Asymmetric information is often easier to accept as it tends to support the project in execution and the easier opportunities for the team to adopt; asymmetric information engenders popular support.

From the interviews with the Client group interviewees there was little understanding of the term ‘asymmetric information’, the greater the experience of the EPCM Company group and the Client
the less likely it would appear that asymmetric information would be allowed to proliferate and bias decisions.

There was uncertainty in the interviews as to the understanding of the implications asymmetric information in the mining project environment though the term was understood. This was most significant in the embedded EPCM Company and the client environments.

Asymmetric information is, from the literature review one of the main causes of cognisant project failures. From the interviews it was also identified that asymmetric information can be compounded by the selective understanding and proliferation of the information received. So the asymmetry can be induced by the transmission and interpretation of the information received.

From the interviews it was understood that asymmetric information can be detrimental to the execution of the project. Asymmetric information creates a bias in the project execution that can impact on the project deliverables and generate unnecessary costs. Targets can be unrealistic which can place the project execution team under duress to achieve unrealistic targets and manage unrealistic costs. For the EPCM Company this can have a consequential cost on the integrity of the project execution team.

When asymmetry is fully understood and managed this could prove to be a significant beneficial aspect of mining project management.

Despite this there was a general understanding of the aspects that could be managed to compensate for asymmetric information in the mining project environment. Asymmetric information can be compensated for through the application of tried and tested project management principles of correcting the balance of project information, ensuring the information is correlated and obtained from different sources in the client organisation, and the output information is peer reviewed by independent personnel. Round-table workshops that are chaired well can also ensure the information to be acted on by the project is well founded and unbiased.

From the interviews it was apparent that effective communication was one of the consequential big challenges occurring in the International project management environment. Effective communication creates an environment where everyone associated with the project is aware of what is happening and is aware of the expectations that have been placed on them, with particular importance to the geographically dispersed teams.

From the interviews it was stated that in the International environment the project communication has to be monitored at all times. This will ensure effective synchronisation of the dispersed offices and teams.

Good and efficient communication creates awareness and creates an environment where people can make good decisions. From the interviews it was also noted that communication improves the project efficiency and creates an environment of trust and understanding.
From the interviews it was noted that formal communications have to be peer reviewed prior to distribution this is to ensure the information given to the client is accurate, appropriate and unambiguous.

The stakeholder group for the mining house can change and this can go unnoticed, the stakeholder group has to be notified in the correct sequence and by the correct person. The stakeholder group listing has to be managed and refreshed regularly to ensure all of the people who need to know about the project are on the list, and their requirements are understood and satisfied.

The use and application of electronic communication has to be effectively managed as the communications can go outside the intended distribution group. The electronic communication to the client group must be accurate and appropriate at all times.

From the interviews there was a general consensus that good communication was paramount to the effective management of client perceptions, but the communication has to be honest and accurate. Communication has the ability to create a common understanding, and concerns have to be addressed in good time. Communication has the direct ability to create an environment where sound decisions can be made based on this common understanding.

7.26 Project close-out
7.26.1 Project close-out - introduction

One of the common features of large multidiscipline mining projects is the post project changes that have to be implemented in the period directly after project completion. The reasons for these changes are varied and can result from the client not getting the full benefit of the completed project from start-up, delayed start-up, difficult commissioning, increased maintenance costs and reduced life of critical components.

Studies indicate that inexperienced clients could be pressed for early design freezes that could result in later rework to attain the required outputs from the plant. Design freezes should only be implemented when the requirements have been fully identified and fully satisfied by the output.

It is seldom that the complete scope of a large multidiscipline mining project will be established up front, there should therefore be an acceptance from all parties to the project execution that there will be changes and some of these changes could be significant and fundamental.

From the literature the principle causes of post project completion changes are items overlooked during the engineering of the project and items overlooked by the users when establishing the requirements for the project. Layered on top of this are aspects of the project that would only become known during the project execution such as changes in user demands and changes in the conditions surrounding the project.
These aspects can be mitigated by improved engineering, and greater ‘end user’ involvement from a project and operational point of view. On top of this could be layered the implementation of a flexible design strategy and a flexible implementation model. The anticipation of post project changes would therefore warrant a flexible approach to the project execution and the implementation of an operationalisation strategy during the execution of the project.

7.26.2 Project close-out - recommendations

Life cycle costs are considered in the execution of large multidiscipline mining projects. In general though, from the interviews the plant design and plant performance characteristics are the first aspects to be considered in the generation of the design input data.

From the interviews large multidiscipline mining projects are conservative and reasonably conventional and the technology being used in the completion of the project deliverables is well established. Most of the projects reviewed in the interviews had however not reached the point of commissioning and hand over.

One of the historical projects discussed was handed over to the client at the point of shaft commissioning and some of the infrastructure had not been completed. As such the client implemented significant changes to the conveyors and mud handling systems, in addition to this it was later identified that the project would not yield the returns as would be required to suit the client business plan. The client has since undertaken to address significant changes to the projects designed infrastructure.

The root cause of post project completion changes can be traced to the client or from the EPCM Company. The client can change fundamental design aspects or introduce budget constraints which impact on the project program execution. From the EPCM Company group interviewees’ point of view there can be a lack of involvement from the client in the design process and a failing to agree the conceptual layouts and equipment configurations in the early stages of the project design. The client needs to understand the importance of this involvement.

In addition to this involvement by the client, it is important for the client design criteria to be fully documented and agreed, and a clearly defined completed plant performance standard established. Often changes in the client owner’s team would be a source of fundamental design criteria changes. There could also be a significant ‘key person’ change in the client project team which introduces a change in the client design criteria.

From the interviews it was established that the majority of the post project changes were founded in the fundamental philosophy of certain aspects of the process plant, the requirement for additional production capacity, additional monitoring of performance and production efficiencies. The impact of these changes would have to be highlighted to the client and in addition the impact on the cost and program would have to be fully evaluated and accepted prior to implementation.

Changes in the project deliverables inevitably result in additional cost either in the design time or in the cost of the completed package. Along with the additional cost there would often be an
increase in the time required for the completion of the package. This would either be in the completion of the design packages resulting in a delay in the start of the procurement cycle or delays in the completion of the procurement and supply cycle due to additional package scope. According to the interviewees the delays and rework in the design office can have a secondary effect of demoralising the project team and have a ‘knock on’ effect on the other aspects of the project design. ‘Crashing’ a design package can result in the application of additional management resources thus additional EPCM Company costs.

In the execution of the project there can be a capital constraint introduced or the provision of inadequate budgets for the full project execution. This may result in a reduction in scope for the project, delaying this activity to later in the project life. The EPCM Company can also be in a position where the design or the interpretation of the design criteria can be proven inadequate. Each of these aspects will introduce a cause for post project changes.

The EPCM Company needs to respond to these post project changes with a thorough understanding of the design processes to be followed and the focus on more client involvement. The reduction of post project completion changes would only be reduced by the inclusion of a broader group of client stakeholders in the design processes to ensure the final deliverable reflects the requirements of the operational personnel.

Through application of this process there is a greater assurance that the final product will fully address the clients stated and unstated requirements.

In obtaining this balance between client project personnel and operations personnel the EPCM Company can be assured that that what is delivered is within scope and within budget.

7.27 Conclusion

In this chapter the literature review key aspects and the interview responses have been merged to generate a series of recommendations and to identify areas where project execution benefit to the EPCM Company can be realised.

Some of the key industry trends have been identified and areas where the PMBoK® (2013) cannot be seen to directly apply to the execution of the large multidiscipline mining project by a third party.

This chapter leads directly into chapter eight where the revised project model for the EPCM Company working in the large multidiscipline mining project environment is developed.
Chapter 8: Proposed PMBoK® model additions

8.1 Introduction

The PMI PMBoK® currently in the fifth (2013) edition is well established in the industry as a model for project management so this has been chosen as a framework and foundation for the EPCM company enhanced model.

General acknowledgement is given to PMI PMBoK® (2013) for the knowledge areas and the process groups identified in the sections below.

In this chapter the recommendations developed in chapter seven are synthesised and structured into an overlay of the nine PMBoK® knowledge areas and the five process groups as mapped in table 8.1 below.

Table 8.1 derived from the PMBoK® Guide Construction extension (2016) process groups and knowledge area mapping.

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In each of the sections below there is an extract from a table identifying each of the process for the knowledge area. Where the text has been struck through then there is no specific addition to that process identified in the recommendations. The additions have been segregated into inputs, tools and techniques, and outputs.

### 8.2 Definition and general precepts of a large multidiscipline mining project

The large multidiscipline mining project can be defined as having high capital cost, long duration, program urgency, technological challenges, logistical demands, multidiscipline inputs and the creation of a ‘collaborative virtual enterprise’ for the execution of the project. Typically, this would be in excess of ZAR 1 billion, in excess of three years in duration, have multiple deliverables and execution complexity. The EPCM company should continuously evaluate the value of the project to the client.

In the execution of large multidiscipline mining projects, the EPCM company should be aware of the necessity for developing a project specific management strategy for the large project. The project management processes would be more reflective of the project requirements and would have to become more comprehensive. Higher levels of project management have to be developed, demonstrated and practised.

In the execution of large multidiscipline mining projects, the EPCM company should take into consideration the necessity for agility in project execution. This would be a particular requirement where the project is ill defined but there is a schedule necessity. The client should be aware of the project necessity for agility.

### 8.3 Project integration management

As quoted previously from PMBoK® (2013: 63) project integration management is a collection of processes and activities to identify, define, combine, unify and coordinate the activities within the project management process groups.
Incorporated in the project integration management the PMBoK® (2013) discusses the business case. This defines whether the project is viable from a business standpoint. The client project sponsor should agree the scope for the project and the limitations for the business case.

Activities in this knowledge area cover all project management process groups; initiating process group, planning process group, executing process group, monitoring and controlling process group and the closing process group.

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<thead>
<tr>
<th>Knowledge area</th>
<th>Project management process groups:</th>
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<tr>
<td></td>
<td>Initiating  Planning  Executing  Monitoring &amp; Controlling  Closing</td>
</tr>
<tr>
<td>Integration management</td>
<td>Develop project charter  Develop project management plan  Direct and manage project execution,  Monitor and control project work Perform integrated change control  Close project or phase</td>
</tr>
</tbody>
</table>

8.3.1 Project integration management process groups

The process groups identified under project integration management include the following:

- **Develop project charter,**
  - **Inputs**

In developing the business case for the project the EPCM company and the Client should be aware of asymmetry of information being presented for the project configuration. All sources of information need to be considered, thorough and valid input information is required that is free of bias and the input and output information needs to be peer reviewed.

The project team should consider using the project premortem or forethought process as a review technique to improve the project review.

The essential differences between the Client Sponsor and the EPCM Sponsor should be considered. The EPCM company project sponsor acts in the best interest of the EPCM company and the client. The EPCM company project sponsor should be an executive of the company and should have excellent business contacts. The EPCM company project sponsor should, ensure the company support creating and environment for success, approve the project costing, appoint and mentor the senior team, maintain oversight of the project and challenges the execution team, liaise with the senior client management, ensure the goals of the EPCM company are achieved such as retained learning, profitability and improved company image. In sponsoring multiple projects the EPCM company project sponsor should be capable of managing project complexity. Managing the project complexity is fundamental to managing the project.
○ Tools and techniques

In exercising the tool of forethought or the project premortem the project team should be aware of the overinvested stakeholder. The review discussions should be well managed and all-inclusive to ensure all views are included.

The EPCM company should develop procedures to determine the complexity and uncertainty of the project. This procedure would examine the project size, the project interdependencies and the project variety. The number of stakeholders must be considered an aspect of project uncertainty and the project uncertainty as an aspect. Uncertainty management strategies must involve the client stakeholder group. This will ensure the project team remains well motivated.

In managing the project uncertainty, the EPCM company should consider the following aspects; vague or incomplete information, project complexity and instability or randomness (chaordic).

The EPCM company should regularly evaluate the project complexity taking into consideration the changing uncertainty, evolution of technology development, project pacing, socio-political complexity, diverse cultural team make-up, dynamics and stakeholder changes. This will assist in managing the changing project risks.

The EPCM company project sponsor should be in a position to identify periods of project uncertainty and be instrumental in driving for clarity with the client.

The EPCM company project sponsor must be able to choose the optimum time to become involved in the project.

The EPCM company project sponsor should create an environment for project success.

○ Outputs

There is a tendency to overload the EPCM project sponsor with other activities such as business development. The EPCM company should therefore ensure that the EPCM project sponsor has sufficient time available for the monitoring of the project activities and time available for intervention as and when this is required.
• **Develop project management plan,**
  
  **o Inputs**

The EPCM company should allow adequate time in the initiation phase of the project to develop the project management plan. The more time that is provided for this activity at the start of the project generally the better the plan.

The EPCM company should ensure the “trade-off” studies performed during the feasibility studies for the project are as all-encompassing and as complete as possible to minimise significant design uncertainties. The decisions taken should include the latitude required for future options to add value to the project.

**o Tools and techniques**

In developing the project management plan consideration should be given to the last planner technique particularly where the project size and complexity warrants multiple layers of planners. The last planner adds the detail to the execution planning and identifies the buffer of tasks to ensure the execution team is constantly occupied.

In developing the project management plan the EPCM company should take into consideration the multiple project scenario presented by the project and the necessity to manage the multiple project or the challenges presented in managing the project execution in different phases. This can present a significant project risk.

In directing and managing the project work the EPCM company should establish plans for the management of project uncertainty. The uncertainty management processes should include the client as a key role player to develop uncertainty awareness, sharing uncertainty information, and a thorough and systematic assessment and resolution process.

In developing and implementing uncertainty management plans the EPCM company should consider the consistent application of established processes, an effective corporate body of knowledge and an effective uncertainty management culture.
• Direct and manage project work,
  
  o Inputs

The EPCM company should be aware that in the execution of a project, gaps in the understanding of project deliverables can develop between the EPCM company and the Client, and the EPCM company and the vendor or contractor.

The EPCM company should ensure all the relevant stakeholders are involved in the establishment, definition and scoping of the project deliverables. This will assist in ensuring the final completed project meets the clients requirements.

In the management of project work the EPCM company should consider agile and improvisational project management. The aspects of improvisational project management should include the aspects of creativity, intuition, innovation and bricolage. The project execution team should contain the experience and maturity to control the agility aspects. This will assist in the management of the LMM Project.

  o Tools and techniques

The EPCM company should develop procedures for the expediting and delaying of design activities. The client should be aware of the risks of expediting design activities where all of the design input information and contingent design data is not known.

Gaps in the understanding of project deliverables can develop between the EPCM company and the Client, and the EPCM company and the vendor or contractor. The EPCM company should develop procedures for the identification and control of these gaps.

• Monitor and control project work,
  
  o Tools and techniques

The success criteria for an EPCM company though including the success of the project delivered to the client should provide for the development of legacy criteria. Therefor the EPCM company should establish and maintain a set of criteria for determining the project execution success from the point of view of the EPCM company. Such criteria would include the following aspects:

  • Client satisfaction.
  • Team development.
  • Improved International performance.
  • Knowledge development.
• Enhanced company image.

Included in the project success metrics would be the aspects of minimal post project changes and safety performance. Included in the client success metrics would be enhanced business performance, productivity and improved or maintained production.

The EPCM company should implement procedures to ensure the physical project execution is optimised. This should include but not be limited to the optimisation of fast tracking opportunities, modular plant design for early commissioning and availability for production. This should be achieved without increasing cost, compromising quality, inefficient use of materials or over stretching resources.

• Perform integrated change control,

  o Tools and techniques

Scope changes can be a destabilising influence on the project team. Therefore changes in project scope, budget and schedule have to be acknowledged by the client, communicated to the project team, and then normalised.

  o Outputs

In aspects of the project execution where the uncertainty aspects have been worked around by the project execution team these actions must be recorded and acknowledged by the client.

Where aspects of agility have been practised in the execution of the project these should be recorded and acknowledged by the client for the complete project record.
• **Close project or phase.**
  
  o **Tools and techniques**

  The EPCM company should develop and implement a process or processes for the capturing of knowledge (or operational assets) developed during the execution of a project, this process would include the following aspects:

  - A corporate knowledge strategy,
  - Defined responsibilities for knowledge management,
  - A defined and understood knowledge structure,
  - Training in knowledge management,
  - Time, facilities and forms for knowledge sharing,
  - Information systems and software,
  - Data storage processes for easy recovery or retrieval.

  The knowledge management processes should be as straight forward as possible.

  o **Outputs**

  The EPCM company should ensure the key learning points from project failures should be fully documented and captured into a project execution database. Where necessary these should be expanded into project execution training sessions.

  The capturing and use of ‘acquired knowledge’ should become part of the EPCM company culture, and define a significant part of the company’s project management activities. Therefore, as far as is possible the EPCM company should encourage the divulgence and retention of tacit knowledge. The mentoring and coaching processes should be included in this activity and the effectiveness of this process should be monitored and managed.

  The EPCM company should ensure the lessons learnt and explicit knowledge generated during the execution of the project is captured into a structured and accessible project knowledge database.

  **8.4 Project scope management**

  As quoted previously from PMBoK® (2013) project scope management are the processes required to ensure that the project includes the work required to ensure the project is completed successfully. Scope management is defining and controlling what is and what is not included in the project.

  Project scope is defined by PMBoK® as the work to be performed to deliver the product or service. The requirements include the conditions or capabilities to be met by the completed project, the
requirement have to be in sufficient detail to be captured in the scope baseline and provide a basis for measurement. From the project scope requirements the WBS can be defined and developed. Activities in this knowledge area cover the following project management process groups; planning process group and the monitoring and controlling process group.

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<th>Knowledge area</th>
<th>Project management process groups:</th>
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<td>Initiating                                              Planning                    Executing                  Monitoring &amp; Controlling</td>
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<tr>
<td><strong>Scope management</strong></td>
<td>Plan scope management                                   Collect requirements               Define scope Control scope</td>
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<td></td>
<td>Create WBS</td>
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</table>

8.4.1 Project scope management process groups

- **Plan scope management,**
  - Tools and techniques

  Uncertainty can have a detrimental effect on the project execution team, therefore in planning scope management, the EPCM company should plan for execution and project definition uncertainty.

- **Collect requirements,**
  - Tools and techniques

  In the collection of project requirement due cognisance should be given by the EPCM company to the introduction and proliferation of asymmetric and biased information. Asymmetry can originate from conditioning, preselection of information, interpretation, preferential capturing or deliberate distortion.

  In the collation of project requirements, the EPCM company, with the client should identify aspects of the project that can be optimised to generate early returns for the client. This can be plant made available for other operations, plant that can be used for the completion of the project or plant that can be used for the early generation of revenue. This can add significant value to the project.

  The EPCM company should ensure as far as possible that the input information presented is bias free and develop procedures for the management and validation of project defining information. This can be achieved by, amongst other activities, peer review and comparison with other ‘reference’ projects.
Define scope,

- Tools and techniques

In defining the project scope, the EPCM company should ascertain and obtain agreement on those aspects of the scope that are uncertain or could be subject to change in project execution. In the process of clarifying these items the EPCM company should as far as possible include the client operational personnel to ensure there are minimal post completion changes to the project deliverables. Uncertainty management is fundamental to the successful management of the LMM Project.

Create WBS,

- Tools and techniques

The WBS granularity should be optimal so as not to introduce the complexity of too many work packages therefor in creating the work breakdown structure consideration should be given to the granularity, or element sizing of the work breakdown structure.

Validate scope,

- Tools and techniques

In validating the project scope, the EPCM company should ensure the client operational personnel are involved in the commissioning and acceptance. This can eliminate post project changes and accelerate the acceptance, commissioning and operational readiness of the plant.
• Control scope.

No specific additions identified

8.5 Project time management

As discussed previously from PMBoK® (2013: 141) project time management includes the processes required to ensure the project is completed on schedule.

Activities in this knowledge area cover the following project management process groups; planning process group and the monitoring and controlling process group.

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<td>Time management</td>
<td>Plan schedule management</td>
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<td></td>
<td>Estimate activity durations</td>
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8.5.1 Project time management process groups

• Plan schedule management,
  o Tools and techniques

Project disruptions are detrimental for team stability and should be normalised as quickly as possible. The EPCM company should therefor develop procedures for the management of project disruptions. The EPCM company should normalise the disruption as soon as possible and retain, as far as possible the core of the project execution team.

In establishing the procedures for ‘schedule management’ the EPCM company should take into consideration the project complexity, global implementation complexity, the WBS granularity, stakeholder commitment, time for end user training and a ramp up to full production. These aspects are essential for the successful completion of the project.

• Define activities,

No specific additions identified.
**Sequence activities,**

No specific additions identified.

**Estimate activity resources,**

- **Inputs**

  The EPCM company should give consideration to the detailed modelling of the human resource requirements for the project execution. This will enable the EPCM company to allocate resources from the pool of resources available.

**Estimate activity durations,**

No specific additions identified.

**Develop schedule,**

No specific additions identified.

**Control schedule,**

- **Inputs**

  In controlling the schedule, the EPCM company should, for the benefit of the client be aware of opportunities for schedule optimisation and enhancing the efficacy of the project. This can be in the form of fast tracking, implementing new technology, optimising plant design and earlier plant availability. As a part of achieving this, the EPCM company should carry out risk assessments.

  Schedule updates are often overlooked when scope changes are introduced. The EPCM company should ensure the master project schedule is updated as required when there are scope changes. The scope changes must be incorporated failing to do so will generate significant schedules burdens on the site teams.

- **Tools and techniques**

  ‘Fast tracking’ is commonly used when the program needs to be accelerated. The EPCM company risk assessments regarding the fast tracking should include the aspects of incomplete design, resource stretching and the bypassing of essential project control steps.
8.6 Project cost management

As quoted previously PMBoK® (2013) states that project cost management is the application of processes for the planning, estimating, development of budgets, financing, funding, managing and the controlling of costs so that the project can be completed within budget.

Activities in this knowledge area cover the following project management process groups; planning process group and the monitoring and controlling process group.

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<td>Cost management</td>
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8.6.1 Project cost management process groups

- **Plan cost management,**
  - **Inputs**

  The estimating process can introduce a significant bias into the costing of the project. The project planning has to take into account the staffing requirements for the estimating team. The estimating team has to be adequately skilled and experienced, and access has to be provided to the ‘lessons learnt’ and the knowledge databases. This will assist in establishing a realistic budget.

- **Estimate costs,**
  - **Inputs**

  In estimating the costing of the project the EPCM company should ensure the estimating team has access to the necessary resources. Due cognisance should be made of scope definition biasing and validity of the costing received from the vendors resulting from vendor fatigue, market saturation and preferential tendering. This will assist in establishing a realistic budget.

- **Determine budget,**

  No specific additions identified

- **Control costs.**

  No specific additions identified
8.7 Project quality management

As quoted previously from PMBoK® (2013) project quality management describes the processes and activities that determine the quality policies, objectives and responsibilities so that the project will meet the requirements for which it was undertaken.

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<td>Quality management</td>
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Activities in this knowledge area cover the following project management process groups; planning process group, executing process group and the monitoring and controlling process group.

8.7.1 Project quality management process groups

- **Plan quality management**,
  - **Inputs**

  The EPCM company should apply consistent and agreed quality management criteria. In planning quality management, the EPCM company should ensure the defined quality aspects are applied to the EPCM company processes from the project initiation to the final handover of the completed project.

- **Perform quality assurance**,
  - **Tools and techniques**

  The globally distributed team should be subject to stringent and consistent quality control. In performing quality assurance, the EPCM company should establish procedures for the monitoring and control of design activities performed by globally distributed team members and design centres. This would include the control of the design input information placed on the project servers, specifications and the verification of the design output information.

- **Control quality**.
  - **Tools and techniques**

  ‘Fast tracking’ should not encourage bypassing of the standard quality control techniques. In performing quality control during the execution of the project the EPCM company should ensure that when ‘fast tracking’ aspects of the project the key project control steps should not be bypassed.
‘Tipping points’ are reached when the site execution team is swamped by rework activities. The EPCM company should establish and maintain procedures for the detection, management and control of ‘tipping point’ failures within the project execution teams. Leading indicators could include poor contractor support, excessive rework resulting from non-conformances, uncontrolled scope changes and increasing project complexity. The team performance and the project progress should be monitored.

In controlling the project, the EPCM company should be aware of the ‘tipping point’ aspects of excessive rework and quality control failures. The EPCM company should monitor quality control interventions due to poor contractor selection and excessive rework. The EPCM company should develop procedures for the identification, management and control of ‘tipping points’ in all aspects of the project execution.

8.8 Project human resource management

As quoted previously from PMBoK® (2013) project human resources management includes the processes that organise, manage and lead the project team. The section also refers to the use of virtual teams and reflects on the challenges of managing and directing virtual teams.

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<tr>
<td>Human resource management</td>
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</table>

Activities in this knowledge area cover the following project management process groups; planning process group and the executing process group.

8.8.1 Project human resource management process groups

- Plan human resource management,
  - Inputs

In planning the requirements for the project execution the project sponsor from the EPCM company will be responsible for identifying the project manager. The project manager would be required to identify, select and manage the project team, the stakeholder group, the office support functions and the project in execution.
The project manager should be skilled in managing multiple projects, multiple stakeholders and
the prioritisation of resource allocation. These are the challenges that can be expected in the
execution of an LMM Project.

The EPCM company should identify a project manager with a good culture fit in the client
industry. The client would be expecting a project manager that is familiar with the industry and
there is a need to be able to manage the challenges of an International project team.

The EPCM company project manager should possess skills in communication, leadership and
team building. There should be an understanding of the contractual and commercial aspects of
the project. In addition, there should an understanding of the technical aspects of the project.
When working on International project execution the project manager there would be a need to
understand and manage the socio-cultural aspects of the project execution and project team.

- Tools and techniques

The EPCM company should be able to identify successful team combinations from previous
experience. In establishing the human resource requirements for the project the project manager
should establish the skills and capabilities of the engineering resources and model the project
requirements. In assembling the project team key resources should be identified for mentoring
and knowledge management activities. Mentoring and knowledge management are key project
manager responsibilities.

In identifying the team members, the EPCM company would identify those resources that would
become part of the virtual project team or the shared resources. The EPCM company should
develop procedures for the management and socialising of the virtual project team and the
integration of virtual design centres.

- Outputs

The EPCM Company should set as a key performance indicator the development of the project
execution team. In managing the complex project, the EPCM company project manager should
consider power sharing and empowerment, and an open management style. The project
manager’s key performance indicators should include staff turnover, team satisfaction and
knowledge retention.
For the long duration LMM project there would certainly be a changing requirement for the project execution team make-up. For the project in execution, the EPCM company should require regular planned meetings with the human resource practitioners within the company. These discussions would be required to highlight changing human resource requirements, staff development, performance monitoring and changes in the EPCM company processes.

- **Acquire project team,**
  - **Inputs**

In the acquisition of the project team, the EPCM company should establish and enforce induction processes for induction into the company, induction into the project team and induction into the client environment.

In establishing the project team requirements, the EPCM company should identify key support personnel from the non-project personnel in the EPCM company, this would include but not be limited to the human resources, office services, information technology. The EPCM company should consider developing project management skills within these and other support services.

  - **Tools and techniques**

The EPCM company should develop processes for the acquisition of geographically dispersed project teams and the management and control of these teams in the virtual project environment. The scarcity of resources has developed the requirement for resourcing from the global environment.

The acquisition of the project team in the EPCM company should be a cooperative effort between the project team, human resources and the heads of department in a matrix organisation.

- **Develop project team,**
  - **Tools and techniques**

The EPCM company should establish procedures for the development of the project team members particularly with regard to the enhancement of skills and understanding with a view to retaining the top talent. The retention of key skills should be a prime requirement for the EPCM Company.
The EPCM company should develop processes for socialising the project team to align the project team to the project goals. The processes should provide for the local project team, the site based team, the regionally dispersed team and the international team. For the international team, specific team leaders should be identified. The challenge for the EPCM Company should be to integrate the dispersed project team.

The EPCM Company has to ensure the development of the staff engaged in the execution of the LMM Project. In developing the project team, the EPCM company should institute a process for the mentoring and coaching of staff engaged in the project execution.

- Manage project team.
  - Tools and techniques

The international project and team environment has introduced new challenges for the project management team.

In managing project conflict the EPCM company should establish processes for the management of conflict in the International project environment. The processes should consider the language and cultural challenges, the technical understanding, and contracting practices.

The processes should take cognisance of:

- Local environmental conditions.
- Differing health and safety practices.
- Local legislation and licensing requirements.
- Delays in decision making.
- Information distribution challenges.
- Differing skill levels.

The EPCM company should develop, implement and monitor key staff retention activities based on a strategic intent. This should become a key performance activity for the EPCM Company.

8.9 Project communications management

As quoted previously from PMBoK® (2013) project communication management refers to the processes required to ensure the timely and relevant planning, collection, creation, distribution, storage, retrieval, management, control, monitoring and the final disposition of project documentation.
Activities in this knowledge area cover the following project management process groups; planning process group, executing process group and the monitoring and controlling process group.

8.9.1 Project communication management process groups

- Plan communications management,
  - Inputs

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<td>Communication management</td>
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Often the communication management fails to include the client team thus the communication planning and processes should include the responsibilities of the client regarding communication within the project environment. The client communication protocols should be included in the communication planning.

- Tools and techniques

The LMM project execution team often includes International team members. The EPCM company should develop processes to ensure the communication processes are effective in creating the alignment of the client and the International team members. The communication should be transparent and recent, and the process should be subject to continuous enhancement. This is particularly important in the International project environment.

- Outputs

The LMM Project the stakeholder register could be expected to change frequently as the project moves into new phases. During the execution of the project the stakeholder register should be reviewed and updated regularly by the EPCM company in association with the client.

Information control for the International EPCM Team is critical to ensure a consistent output, therefore for geographically dispersed project teams the EPCM company should develop and maintain a well-structured web based database for the control and distribution of project information.
• Manage communications,
  o Inputs

When practising agile project management in the execution of a project the EPCM company should ensure the client stakeholders are involved in the project scope development and are aligned to the project execution strategy.

• Control communications.
  o Tools and techniques

Asymmetry and bias can develop into a significant project execution risk if not identified and corrected. The EPCM company and the client should establish procedures for the identification and control of asymmetric information. Information communicated in the execution of a large multidiscipline mining project should be substantiated and without bias. Critical communications should be peer reviewed prior to distribution.

  o Outputs

The EPCM company should ensure the information content and distribution in the International arena is effectively managed and monitored. This will be critical for the consistent and compliant output into the project deliverable.

8.10 Project risk management

As quoted previously from PMBoK® (2013) project risk management includes the processes for conducting risk management planning, identification, analysis, response planning, monitoring and controlling risks on a project. Project risk management is executed to reinforce positive events and to minimise the likelihood and impact of negative events.

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</table>
Activities in this knowledge area cover the following project management process groups; planning process group and the monitoring and controlling process group.

8.10.1 Project risk management process groups

- **Plan risk management,**
  - **Inputs**

  In the LMM Project environment some of the risks will go unidentified therefore a planned and improvisational risks management strategy could be of benefit. Therefore the EPCM company should consider an aspect of improvisational agile risk management to ensure that unforeseen project risks and scope changes can be effectively managed.

- **Risk management should be part of the daily activity on an LMM Project therefore the EPCM company should ensure the risk management practices and procedures are entrenched in the ethos of the EPCM company. Even where agile risk management is established as an operating process this should be founded on sound risk management principles.**

- The EPCM company should plan for the ‘project induced risks’ of project complexity and managing diverse groups of stakeholders when carrying risk identification. This would generally be a project management risk. The complexity could be ascribed to technical complexity, International resourcing, multiple project liabilities and project clustering.

  - **Tools and techniques**

  The EPCM company should strive to have an effective, functional, accessible and visible risk management process. The risk management processes should be primarily proactive with an allowance for reactive risk management. Reactive risk management aspects should be recorded and captured in the lessons learnt database.

  Project risks need to exhaustively investigated. The EPCM company should consider some risks to be knowledge gaps, effort should be made to close these knowledge gaps with studies and additional research. The management of knowledge gaps can be seen as managing the project uncertainty.

  In defining the risk management activities, the EPCM company should consider periodic reviews of the risk register and consider the changing emphasis of the work being carried out on the project or on the aspect of the project.
Being a long duration project the LMM Project

The risk management plan should consider the external business risks and the internal operational risks.

- Identify risks,
  - Inputs

In identifying risks, the EPCM company should avoid relying principally on the previous project risk assessments. This can hide some of the unique risks associated with the execution of an LMM Project.

Internal risks are often overlooked or hidden when evaluating the project execution risks. The EPCM company should consider own internal risks when identifying project risks, these could be team risks, technical competence and financial management. These risks should be reviewed with International partners or associates.

Execution risks associated with LMM project execution are generally resident in either the project environment or in the human resource activity. The principle sources of project risks were identified as being introduced by; complexity, uncertainty, International project execution, project execution delays and capital rescheduling or cost overrun.

In identifying the project risks due consideration should be given to the risks associated with the management of multiple or a portfolio of projects particularly with respect to the project manager and the project management team. The risk identification process should be repeated periodically during project execution.

In identifying the risks to the project the EPCM company should evaluate the team risks; correct resources, appropriate team sizing, adequate induction and effective team development. The risks evaluated during this process should consider the regional risk associated with assembling the project execution team.

  - Tools and techniques

The EPCM company should establish procedures for reactive risk management processes as appropriate for dynamic projects.
The risk management process should examine the interaction between the various project in a multiple project environment and the risk assessment outcome should be used as an evaluation tool for other projects.

The risk identification process should evaluate the complexity of managing the broad group of stakeholders; this would be particularly relevant when managing a portfolio of projects across a diverse group of clients. The EPCM company should develop procedures for managing broad stakeholder groups.

In carrying out the risk assessments the EPCM company, along with the client should be identifying the custodian of the risk and ensure the business and the operational risks are evaluated.

In identifying the risks in the LMM project the EPCM company should take due cognisance of the risks associated with the transition from one project phase to another. This could be, for example, transitioning from the initial surface construction to the shaft sinking, or from shaft sinking to shaft equipping.

The EPCM company should subject the risk reviews to internal peer reviews. This will encourage the transferring of lessons learnt from one LMM project to another project.

- **Perform qualitative risk analysis,**
  
  o **Tools and techniques**

  The risk assessment and evaluation processes of the EPCM Company should be as pervasive as possible, therefor the EPCM company should examine the unknown unknowns as residing in the relevant subsystems of results, processes, organisational, tools and goals. The EPCM company should commit resources to continuously evaluating the project risks.

  The EPCM company should commit resources to continuously evaluating the project risks.

- **Perform quantitative risk analysis,**

  No specific additions identified
• **Plan risk responses,**
  
  o **Inputs**

  To ensure the risk assessment is as all-inclusive as possible the EPCM company should consider the secondment of specialist resources as a risk mitigation technique. These could be external experts or specialist vendors.

  o **Tools and techniques**

  In mitigating the project risks the EPCM company should ensure the internal processes of the EPCM company are aligned with the client processes. The process configuration should include; communication strategies, priorities and, technical standards and preferences. This will ensure a greater alignment between the EPCM company and the client organisation.

  o **Outputs**

  In planning the risk responses, the EPCM company should ensure the risk ownership is clearly defined. The risk ownership would be allocated to the client, EPCM company or the contractor.

  Risk management should become part of the project execution ethos. As such the EPCM company should ensure that the project management team are taking due cognisance of the risk management process and the risk responses are effective. Risk management should not be compromised for schedule expediency.

• **Control risks,**
  
  o **Tools and techniques**

  There is a possibility that the risk management activity becomes solely a project start up activity. In controlling the risks, the EPCM company should plan periodic risk management reviews. The risk management review should examine the application of the risk responses to avoid complacency and deliberate avoidance or delaying of risk mitigating activities.

  o **Outputs**

  Risk management has to become part of the project execution ethos. To achieve this the EPCM company should ensure the principle risks and risk responses are communicated to and understood by all persons participating in the project execution.
8.11 Project procurement management

As quoted previously from PMBoK® (2013) project procurement includes the processes required to purchase or acquire the products, services or results needed from outside the project team. Project procurement management includes the contract management and change control processes.

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<tr>
<th>Knowledge area</th>
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<td>Initiating</td>
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<td>Procurement management</td>
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Activities in this knowledge area cover the following project management process groups; planning process group, executing process group, monitoring and controlling process group and the closing process group.

8.11.1 Project procurement management process groups

- Plan procurement management,
  - Inputs

  Relational contracting, employment and outsourcing can be of significant benefit to a LMM Project particularly where plant is to be used by the contractors prior to being handed over to the client for production.

  In the planning for procurement the EPCM company should identify the need for relational contracts with strategic and principle suppliers, and sub-consultants. The relational contract framework should be provided for in the procurement processes and agreed to by the client.

  - Tools and techniques

  In executing a globally sourced project the EPCM company should take into consideration the global sourcing challenges.

  In specifying the approach for procurement in the global environment the EPCM company should take into consideration the regional legislation, logistics, taxation, procurement standards and undertake bribery avoidance.
- **Conduct procurements,**
  - **Inputs**
  
  In conducting the procurement activities, the EPCM company should take into account the risk attributable to procurement delays.

- **Control procurements,**
  
  No specific additions identified.

- **Close procurements.**
  - **Tools and techniques**
  
  In closing the procurement aspects, the EPCM company should ensure the client has received the necessary familiarisation and training in the operation of the plant and/ or equipment.

### 8.12 Project stakeholder management

As quoted previously from PMBoK® (2013) project stakeholder management includes the processes required to identify the people, groups or organisations that could impact or be impacted by the project. The processes have to analyse expectations, identify impact on the project, and develop appropriate management strategies for engaging stakeholders in project decisions and execution. Stakeholder satisfaction should be managed as a project objective.

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<th>Knowledge area</th>
<th>Project management process groups:</th>
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<tr>
<td></td>
<td>Initiating</td>
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<tr>
<td>Stakeholder management</td>
<td>Identify stakeholders</td>
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</table>

Activities in this knowledge area cover the following project management process groups; initiating process group, planning process group, executing process group and the monitoring and controlling process group.
8.12.1 Project stakeholder management process groups

- **Identify stakeholders,**
  - **Inputs**
    
    The EPCM company should periodically review the stakeholder group; this would be required to ensure the stakeholder group information is maintained current and that changing needs are provided for.

  - **Outputs**
    
    The client group must be subject to the same communication strategy as applied to other project team members.
    
    The stakeholder group should be bilateral insofar as there will be certain aspects that would be for the client to address and certain aspects for the EPCM company to address.

- **Plan stakeholder management,**
  - **Tools and techniques**
    
    The EPCM company should develop a procedure for the management of stakeholders. The EPCM company can expect expertise in the management of stakeholders to grow during the execution of the project, this evolution and successes should be documented and used for the induction of new employees into the project.

  The EPCM company should review the lesson learnt records of previous projects when planning stakeholder management. Stakeholder management should be allowed to form around the EPCM company and client company requirements for project specific information.

- **Manage stakeholder engagement,**
  - **Tools and techniques**
    
    Informal communication on an LMM Project is inevitable and beneficial but should be controlled. Therefor the EPCM company should establish guidelines for the informal stakeholder engagement activities. These guidelines should stipulate the limits on nature and content of informal communication with the client and when the informal communication must be transferred into the formal communication channels.

- **Control stakeholder engagement.**
  - **Outputs**
The EPCM company should ensure the stakeholder engagement successes are recorded and maintained in the project lessons learnt registers. This will ensure the stakeholder engagement strategy can be developed.

8.13 Conclusion

In chapter eight the key learning points from the analysis in chapter seven were synthesised into additions to the PMBoK® guide.

This chapter leads into chapter nine where the study is concluded the resolution of the initial problem statements will be examined and the clarification of the initial precepts will be reviewed. The contribution of this study to the body of knowledge regarding third party project management will be identified and the areas for future research in this field will be identified.

Chapter 9: Conclusion

9.1 Introduction

The title of this study is:

‘An Extended PMBoK Project Management Model for Companies Delivering Large Multidiscipline Mining Projects.’

The study consisted of four parts:

Part one presents the introduction to the study contained in one chapter the introduction to and intent of the study.

Part two contains the literature review in three chapters; the EPCM Company aspects of project management, the client aspects of project management and a review of contextual articles.

Part three contains the empirical review in two chapters; the empirical data collection from the interview of project managers and project engineering managers and the decomposition, analysis and presentation of this data.

Part four is the conclusion of this study in three chapters; the study general recommendations and the recommendations for the enhanced model are derived from the results of the empirical analysis and the literature reviewed. Areas for further research are identified and the study is concluded.
The sequence of the thesis chapters is illustrated below in figure 9.1:

![Diagram of thesis chapters]

9.2 Field covered

The field covered by this study is:

Engineering Management – Project Management – Project Management by a Third Party:

This study covered the management of large multidiscipline mining projects by EPCM Companies (third party project management companies) for mining clients.

Large: the project cost being in excess of one billion South African Rand and an execution period in excess of three years excluding the time required for the preliminary studies.

Multidiscipline: requiring the simultaneous application of a variety of engineering disciplines such as; mining, mechanical, structural, civil, electrical, control and instrumentation and project control disciplines such as contract management, safety management, quality management and risk management as examples.

Mining: mining on surface and underground, and mineral processing; falling under the jurisdiction of the South African Department of Mineral Resources and the associated legislation.

Project: according to the PMI PMBoK® (2013) ‘A project is a temporary endeavour undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. The end is reached when the project’s objectives have been
achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists. Every project creates a unique product, service, or result.’

The study examined the intricacies of the management of these projects by a third party project management company or EPCM Company.

The study specifically examined the PMI PMBoK® project management guidelines and identified enhancements to these guidelines to ensure the EPCM Company can better augment project management skills, develop and sustain knowledge databases, create positive project management artefacts and improve overall project delivery performance.

9.3 Limitations of this research

The following limitations for this study need to be restated:

This study was limited to the scoping, execution and closure of large multidiscipline mining projects, the study excluded the tendering for this activity by the EPCM Company and feasibility studies that would be conducted during the selection and promotion of potential projects.

The interviews were limited to senior management personnel involved in the execution of mining projects performed by one EPCM company and there was a single client project manager interview. Due to the sensitive nature of project execution initiatives and project performance it was not possible for the author to interview personnel from other EPCM companies.

The interviewees were all founded in a South African office environment, though some of the projects and project experience was in the International arena.

There was not an opportunity to test the expanded project management model on a project in execution. Due to the protracted gestation period for a large multidiscipline mining project this would have exceeded the planned duration for this thesis completion.

The recommendations were structured around PMI PMBoK® 2013, there are other project management guidelines such as PRINCE 2 and ISO 21500 2012 that could be used as the basis for an enhanced set of project execution guidelines.

9.4 Overview of the study

The study was initiated in chapter one where the thesis was defined, was scoped and structured, the intent of the study was to examine the project context of the EPCM Company and to identify those primary aspects that could be carried forward into and arrange the empirical study. The research methodology was defined in chapter one.

In chapters two and three the study was initiated with an extensive literature review where the literature relevant to project management, project execution and mining projects was selected and reviewed to establish the current best practices in project management, aspects that could result
in project failure, the current research areas and areas of current interest and focus. Due to the discovered paucity of literature in the mining project management field the literature review was not limited to mining project execution but included large infrastructure and engineering projects. Chapter two examined literature more relevant to the EPCM Company whilst chapter three examined literature more relevant to the client.

In chapter four a review of contextual articles from mining periodicals was carried out to provide a background to some of the challenges being faced by the EPCM Company and clients engaged in the delivery of large multidiscipline mining projects.

In chapter five the literature review was used to create a detailed interview questionnaire, in the host company seven interviews were conducted with experienced project managers and project engineering managers. One interview was conducted with an experienced project manager with a mining company. Not all of the interviewees were PMI registered project management professionals.

In chapter six the results of the interviews were analysed under the interview questionnaire headings, the key points from the interviews were identified and trends established where relevant.

Chapter seven was the development of the non-specific recommendations from the interview analysis and from the key points from the literature review.

In chapter eight the recommendations established in chapter seven were refined into an overlay of the PMI PMBoK® knowledge areas and process groups; this is where additions to the model were proposed.

In chapter nine the study is concluded with a reflection on the intent tabled in chapter one, the limitations are restated and the areas for future research on this topic are discussed.

9.5 Results obtained

9.5.1 Problem statement

At the start of the study in chapter one the following statement was made:

‘The large multidiscipline mining project execution environment is becoming more challenging and more complex. As these projects require the commitment of significant capital the client and the investors are asking for quicker returns on the investment and the application of newer technology for enhanced performance. Through scarcity of resources the EPCM Company project execution team is being sourced internationally, activities are being completed in dispersed regional offices, and the project execution sites are becoming more remote and strategically challenging.’

This statement was corroborated by the comments received in the interviews. In addition, the International nature of the large multidiscipline mining project was corroborated by the industry articles reviewed.
‘There is a tendency for project failure in one or more significant aspects, so how can the EPCM Company ensure that despite the outcome of the large multidiscipline mining project there are the residual artefacts of success remain upon the completion of the project?’

This statement was corroborated by the literature review, and the proposed remediation aspects substantiated by the interviews. The proposed enhancements to the PMBoK® guidelines identify those items that are required for the establishment and management of the EPCM Company project execution artefacts.

‘The importance of building a project execution legacy within the EPCM Company has not been identified and the importance to the EPCM Company of developing and entrenching knowledge management processes and key staff retention strategies has not been fully identified.’

The statement above was substantiated by the comments received in the interviews. In the EPCM Company recommended enhancements to the PMI PMBoK® guidelines the key aspects of the project execution legacy development and entrenchment have been highlighted.

‘EPCM Company success is not necessarily derived from the successful completion of the project deliverable for the client but is more likely to be derived from an enhanced reputation for successful and consistent project delivery, enhancement of EPCM Company personnel skills and an expanded knowledge and data resource.’

This statement was substantiated by the comments received in the interviews. The consequential benefits to the EPCM Company performance and the consequential benefits to the client were identified.

‘It is presumed that an extended and enhanced set of project execution and management criteria are required for the EPCM Company.’

With the PMI PMBoK® guidelines as a widely respected basis for effective project management an additional and extended set of project execution and management criteria and processes based on these guidelines have been developed.

9.5.2 Sub-problems

In addition to the main problem the following sub-problems were identified in chapter one:

‘The project execution complexity places inordinate demands on the EPCM Company for effective project delivery in the international environment that has not been fully determined.’
This sub-problem was corroborated by the literature review and in the interviews. This has been addressed in the general recommendations and has been addressed by the enhancements to the PMI PMBoK® guidelines.

‘The complexity of managing multiple projects has not been identified and the importance to the EPCM Company of managing project complexity and uncertainty in the project execution strategy has not been identified.’

This sub-problem was corroborated by the literature review and in the interviews. The importance of managing project complexity was addressed by the enhancements to the PMI PMBoK® guidelines and the management of project uncertainty was similarly addressed.

‘The fundamental difference between the Client and EPCM Company perceptions of project success and failure has not been determined.’

This sub-problem was corroborated by the literature review and in the interviews. The differences were identified in the general recommendations tabled in chapter seven. Cognisance was taken of these differences when the enhancements to the PMI PMBoK® guidelines were drafted.

‘The importance of being able to develop an agile and innovative approach to the management of large multidiscipline mining projects has not been determined.’

This sub-problem was corroborated by the literature review and in the interviews. Within the EPCM Company large multidiscipline mining project environment it was generally accepted that an agile and innovative project management approach would be beneficial in the project execution. It was accepted that this approach would have to be accepted by the client. The EPCM company would require experienced project team members to ensure the success of this approach.

‘The benefits of ‘relational contracting’ with key contractors and partners in the delivery of large multidiscipline mining projects has not been determined.’

This sub-problem was corroborated by the literature review and in the interviews. The value of relational contracting was appreciated and was practised in some aspects but in an informal manner. Expanding and formalising this process would be beneficial when delivering a large multidiscipline mining project.

‘The challenges of budget estimating for large multidiscipline mining projects have not been fully identified’
This sub-problem was corroborated by the literature review and the interviews. In general, it was appreciated that complex estimating is an aspect that can generate budget errors. This has been addressed in the recommendations and has been addressed by the enhancements to the PMI PMBoK® guidelines.

‘The importance of identifying and entrenching the tools for project safeguards has not been determined.’

This sub-problem was corroborated by the literature review and the interviews. Greater involvement of the client operational personnel in the project framing and in the project execution would be required. This has been addressed in the recommendations and has been addressed by the enhancements to the PMI PMBoK® guidelines.

‘The importance of identifying and entrenching the tools for the minimising of ‘post project completion rework’ have not been identified or determined.’

This sub-problem was corroborated by the literature review and the interviews. Greater involvement of the client operational personnel in the project framing, in the project execution and in commissioning would be required. Time has to be provided in the project planning for training client personnel to assure greater acceptance of the completed project. This has been addressed in the recommendations and has been addressed by the enhancements to the PMI PMBoK® guidelines.

9.5.3 Precepts

The following new precepts, detailed in chapter one were proposed for the conduct of EPCM activities in the large multidiscipline mining project environment:

‘Establishing and utilising the ‘new success criteria’ for the EPCM Company will enhance the project stakeholder’s ability to achieve net project success.’

This precept was corroborated by the literature review and was substantiated by the interviews in so far as the success metrics and the development of the EPCM Company project execution artefacts were considered to be beneficial to the EPCM Company. It was inferred through the interviewee experience that this would enhance the stakeholder’s ability to achieve net project success.

‘Understanding the causes of project failure and the determination of broader holistic success criteria will assist the EPCM Company in determining the contributors to project success.’
This precept was substantiated in the interviews. The interviewees understood that there were different success criteria for the EPCM Company.

‘Understanding and managing the sources of bias and asymmetry originating from the participating project stakeholders will improve project selection and execution through improving the return estimation, costing, risk identification, risk mitigation and project planning.’

This precept was corroborated in the literature review and substantiated in the interviews. This was carried forward into the proposed enhancements to the PMI PMBoK® guidelines for project management by the EPCM Company.

‘Understanding, identifying and managing project complexity and uncertainty will improve project execution success.’

This precept was corroborated in the literature review and substantiated in the interviews. This was carried forward into the proposed enhancements to the PMI PMBoK® guidelines for project management by the EPCM Company.

‘The acceptance and adoption of an agile, adaptive, and bespoke project management strategy will assist in the delivery of large multidiscipline mining projects.’

This precept was corroborated in the literature review and substantiated in the interviews. The adoption of an agile, adaptive and bespoke project management system for the management of large multidiscipline mining projects will assist in the delivery of the project.

‘Developing cognitive, structured and embedded project safeguards will provide enhanced project success.’

This precept was corroborated in the literature review and substantiated partially in the interviews. This was carried forward into the proposed enhancements to the PMI PMBoK® guidelines. The adoption of a deliberate strategy of embedding early project value and project safeguards will enhance project success and enhance the value of the project to the client.

‘The deliberate implementation of a focused relational contracting strategy will assist in project delivery through garnering greater key vendor support for successful project execution.’

This precept was corroborated in the literature review and substantiated partially in the interviews. This was included in the proposed enhancements to the PMI PMBoK® guidelines. It is proposed that a ‘wide view’ be taken on relational contracting.
9.6 Recommendations derived

The recommendations derived from this study is for the EPCM Company involved in the delivery of large multidiscipline mining projects to adopt a set of introspective values that will challenge and define the EPCM Company.

The EPCM Company should understand as a fundamental that the management of a project as a third party is intrinsically different to managing a project as a first part project manager. The EPCM Company has a responsibility to deliver the project to meet the client needs and to meet the needs of the EPCM Company.

The EPCM Company should set as a primary objective the enhancement of skills and the enhancement of knowledge. This would be the lasting benefit that the EPCM Company would accrue from the execution of projects on behalf of clients.

The skills and knowledge acquired by the EPCM Company should be employed to the benefit of the client. The EPCM Company has the benefit of broad exposure to many projects over a period of time with a variety of clients in an international arena that is often not available the mining client.

9.7 Key findings of the study

The study has identified the necessity to identify the key differences between the management of a project from the client group perspective and the management of a project from a third party EPCM Company viewpoint.

The EPCM Company should be aware of and correct for biases and asymmetry in information.

The EPCM Company and the client should identify project safeguards that can add value to the project with early revenues, future expansions and end of life options. The EPCM Company should take actions to minimise post completion rework and the project close out should ensure full client integration.

The EPCM Company should be in a position to optimise the project during execution to mitigate risk, optimise schedules and reduce cost.

The EPCM Company should be in a position to adopt a flexible and innovative project management methodology. The project management approach should address the inherent complexity and uncertainty inherent with large multidiscipline mining projects. The EPCM Company in conjunction with the client should consider adopting an agile and improvisational project management methodology.

The EPCM Company should develop communication processes to ensure the project execution resources, even when located in remote offices are fully integrated.

The project sponsor and project manager should be experienced in managing multiple project and project uncertainty. The risk management processes should take into consideration the EPCM
Company project management risks originating in project complexity, managing the multiple stakeholders.

In addition to this the EPCM Company should establish and implement procedures for the creation and sustainment of assets and artefacts of project execution.

The EPCM Company should ensure as far as possible that key staff members are retained in the organisation and that resources are applied to training and developing personnel.

The role of the EPCM Company project sponsor was reviewed and seen to be divergent from the role of the client project sponsor. The EPCM Company project sponsor has to be in a position to manage the complexity of the project environment and choose the optimal time to be involved in the project execution.

9.8 Contribution of the study

9.8.1 Practical contribution

As a practical contribution this study has identified some of the challenges being faced by the EPCM Company executing large multidiscipline mining projects on behalf of clients.

This study has generated a set of additional aspects to enhance the PMBoK® guidelines; the additional aspects are applicable to the EPCM Company or the third party project management company.

The objective of these enhanced guidelines is to give assurance that the EPCM Company will have artefacts of project management success enhancing the value of the company and improving project management performance. The enhanced guidelines will also give the EPCM Company insight into the client originating project complexities.

Investors require assurance that the project to be executed will meet the stated objectives regarding time, cost, quality and performance, where an EPCM Company is using these enhanced guidelines the project owner and investor will have greater assurance of project success.

9.8.2 Theoretical contribution

As a theoretical contribution this study has identified aspects of large multidiscipline mining projects that require a new paradigm in project management and project execution. The large multidiscipline mining project requires a flexible and innovative execution strategy that requires experienced project execution personnel.

This study has identified those management tools that the EPCM Company should ensure are implemented to assure consistent project execution performance.

In addition to this this study has identified some of the key differences between the first and third party vision of project management.
9.9 Future research areas

There are areas for future research in the area of EPCM or third party project management and managing large multidiscipline mining projects.

The EPCM Company can add value to the execution of large multidiscipline mining projects for clients over and above simply the temporary allocation of specialist human resources to the client organisation. The value added can be through the benchmarking against completed projects, access to extensive execution databases, the application of experienced project personnel and the application of globally shared resources.

This research was conducted primarily in the large multidiscipline mining project environment, the same research process could be tested in other large multidiscipline engineering projects such as power generation plants, large national infrastructural developments and petro chemical plants.

Though this study was referenced back to the PMBoK® 2013 guidelines the study could be ‘back dropped’ against PMI industry specific guidelines, ISO 21500 2012 and PRINCE 2.

The enhancements to the PMBoK® guidelines as detailed in chapter eight have not been tested on a project in execution; this would be an extensive exercise as some of the reference projects would take many years to execute. It is however recommended that these enhancements be adopted by the EPCM Company and the efficacy of these recommendations evaluated through execution.

One of the interviewees intimated that additional project knowledge areas, similar to the two included in the Construction Extension could be added to the ten described in the guide to the project management body of knowledge. These additions would include; project safety management, project contract management, project engineering management, project environmental management and project construction management. These could be developed into additional areas for research even though, as discussed, construction project management has been examined by PMI and is the subject of a specific extension to the body of knowledge. The specific challenges presented by large multidiscipline mining projects could merit a specific PMBoK® extension.

This study examined primarily the project execution processes, the areas of EPCM Company tendering and feasibility study execution could be included in future research.

This study gathered primarily the opinions of the experienced senior project management staff resident in the EPCM Company. There was only one interview conducted in the client group. Future studies could examine the efficacy of the PMI PMBoK® guidelines in the large multidiscipline mining project from the view point of the client or first party to the project.
9.10 Conclusion

This study, through the literature review and the structured interviews has corroborated the problems and sub problems and has supported the initial precepts. Through this process the key differences between managing a project as a first party and third party project management group were identified, recommendations were derived and an extended project management model was established.

The extended project management model for the EPCM Company delivering large multidiscipline mining projects is recommended as a means for enhancing overall project success for all stakeholders.

The extended project management model is recommended as a means for ensuring the EPCM Company has residual artefacts to enhance future project performance.
Part 5 - Appendices

Appendix 1 Bibliography

1.1 Bibliography: Literature review


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