School of Civil and Mechanical Engineering

Mega-Project Engineering-Management Processes: Pre-Planning Phase Evaluation for Construction and Mining

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DECLARTION

The researcher confirm that this thesis is his own work and the best of his knowledge and belief it contains no material previously submitted or published by any other person or to any other university or educational institution except where due acknowledgement has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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Date: 14/12/2015

ABSTRACT

Mega-projects around the globe have encountered difficulties in delivery. Over-time, cost overruns starting from the design phase, through start-up, the construction phase, and then delivery have categorised mega-project progressions; delay stemming from the planning phases and implementation during construction phase, are particularly problematic. Project management professionals, industry practitioners, (alongside academia and developers of software engineering tools) lack a holistic approach that requires starting from the *pre-planning* phase; thus understanding of mega-projects' project management is incomplete. This research builds upon a qualitative research methodology for two case studies, across two 'operational' subsidiaries owned by the KSA public cooperation specialising in mining and infrastructure industry, which implement and manage their own projects alongside multinational companies in the fields of project management, data collection, planning, design, procurement, construction and operation. The research methodology examined longitudinally in-depth face to face semi-structured interviews, with a range of very senior mega-project client/executives and respective design and construction stakeholders; data collection was supported by official approvals from the CEOs' of the two subsidiaries. Through initial cooperation analyses, this research study recorded overruns across two megaprojects with regard to budget, time resources and quality-vagaries during the preparation phase/ prefeasibility/ feasibility/ execution/ & start-up phases, logging many uncertainties during the course of the project lifecycle which caused many knock-on change-orders during the basic design/ detailed design/ procurement/ construction/ delivery and start-up phases. The main aim of this research was to evaluate mega-project management processes applied at the preplanning, design,

construction phases and design, to clarify the process and management approaches used in order to recommend improvement to the process for future projects and to clear up/ reduce/ prevent project issues from derailing deadlines resulting in budget inaccuracies beyond the preplanning phase. Findings reflect the activities of multinational companies and higher management at respective pre-planning phases. These findings include the impact of traditional project management, Stage-Gate Processes, Gate keeper approval, scope change and change order, traditional contracting and tendering, design process and evaluation, and finally the impact of software programs for data collection at preplanning phase on project planning and cost estimation. Findings led to the development of a flow-chart deliverable guide able to enhance traditional project management, address appropriate Stage-Gate Processes, inform Gate-keeper approval, incorporate scope and scope-change order variables, advise upon traditional contracting and tendering applications, position applicably design processes and evaluation, and finally address the impact of software programs for data collection at preplanning phase on project planning and cost estimation. Recommendations for a best practice stakeholder guide have been developed and are presented towards a project-management best-practice/ roadmap for the preplanning stages of mega-project (activities and tasks) progression. An induction program is highlighted as an essential stage in order to explain roadmap steps and to emphasise the importance of processes generally, pre-empting optimum outcomes of each stage for stakeholders and shareholders in order to reduce scope change/ scope creep during mega-project lifecycles.

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ABBRIVATIONS

ARAMCO: ARabian AMerican oil Company

CCC: the Care, Custody and Control of site

CCPaceS: CC Pace Systems

CEO: Chief Executive Officer

CII: The Construction Industry Institute

CP: Closing Process

CS3: Capturing Project lssues

CS4: Examining Project lssues

CS5: Reviewing Stage Status

CS8: Escalating Project Issues

DP3: Directing Project3

DP4: Directing Project4

DP5: Directing Project5

EA: Enterprise Architect

ECM: Engineering, Construction, Management

EPC: Engineering Procurement Construction

EPCM: Engineering Procurement Construction Management

ESH: Environmental, health and safety

EVA: Earned Value Analysis

FEED: Front-End Engineering and Design

FEL1: Front-End loading1

FEL2: Front-End loading2

FEL3: Front-End loading3

HAZOP: HAzard and OPerability study

HV: High Voltage

I/O: Input and Output of control system

IRR: Internal Rate of Return

ITT: International Telephone & Telegraph Co.

IT: Information Technology

KSA: Kingdom of Saudi Arabia

LV: Low Voltage for transformers substations

LSTK: Lump Sum Turnkey

LNG: Liquefied Natural Gas

MCC: Motor Control Centre

MENA: Middle East and North Africa

MTO: Material Take off

MV: Medium Voltage for transformers substations

NASA: The National Aeronautics and Space Administration

NCHRP: National Cooperative Highway Research Program

NPV: Net Present Value

OECD: Organization for Economic Cooperation and Development

OOM: Order of Magnitude Estimates

P&G: Procter & Gamble Co.

PBS: Project Breakdown Structure

PDRI1: Project Definition Rating Index 1

PDRI2: Project Definition Rating Index 2

PDRI2i: Project Definition Rating Index 2i

PDRI3: Project Definition Rating Index 3

PFD: Project Flow Diagram

PID: Project Initiation Documentation

PMBOK: Project Management Body of Knowledge

PMI: Project Management Institute

PMP: Project Management Professional

PRINCE2: PRrojects IN Controlled Environments, version 2

PV: Project Value

PV: Present Val

QA: Quality assurance

QC: Quality Control

QRA: Quantitative Risk Analysis

RM1: Risk Management Study 1

RM2: Risk Management Study 2

RM3: Risk Management Study 3

RM4: Risk Management Study 4

ROI: Return On Investment

SABIC: Saudi Arabia Basic Industries Corporation

SB: Managing Stage Boundaries

SIL: Safety Integrity Level

UK: United Kingdom of Great Britain

US: United States of America

VE: Value Engineering

VIP1: Value Improvement Practice 1

VIP2: Value Improvement Practice 2

VIP3: Value Improvement Practice 3

VP: Vice President

WA: Western Australia

WBS: Work Breakdown Structure

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the Study

The level of mega-project instigation and implementation globally of mining projects has accelerated dramatically in the last ten years; these large scale projects represent infrastructure ventures such as dams, transport facilities, nuclear power plants, mining, and oil and gas exploration. An example of the scale and technical requirement of such mega-projects is illustrated by the recent consortium of 6 multinational companies engaged to realise the $43 billion Liquefied Natural Gas (LNG) project in Gorgon in rural Western Australia (WA). Other examples of mega-projects are exemplified by projects such as the Germany-Italy rail route across the Alpine Mountains, as well as the $50 billion project between the USA and Russia to improve access across the Bering Strait. McKinsey and Co., a multinational management consulting firm, found that 85% of mega-projects around the world exceed budgets and schedules (Rocca 2015).

1.2 Statement of the Problem and Gap of Knowledge

1.2.1 Mega-Projects

Many research studies have focussed on determining the factors affecting scope, quality, time and cost of mega-engineering projects. While there is no standard definition for a mega-project (Brunn 2011), planners and scholars have agreed to define Mega-projects or large scale engineering projects as any activity that has direct or indirect impact on the community, environment and budget and can be stated in monetary terms as being in excess of $1 billion of investment (Merrow 2011). Mega-projects are sometimes also called ‘major programs’ and as a general rule of thumb, ‘mega-projects’ are measured in billions of dollars, ‘major projects’ in hundreds of millions, and ‘projects’ in millions and tens of millions (Flyvbjerg 2014, 6). Mega-projects are inherently risky due to long planning and complex interferences (Flyvbjerg 2006). It has been found that mega-projects have often significant challenges. Flyvbjerg (2014) listed 33 large scale engineering projects that have a history of cost and time overrun, an early example of which was the Sydney Opera House. High profile mega-project examples can be found across a wide range of activities not least in space exploration projects where mega-project ventures carry huge degrees of risk in their requirement for the interaction and the effective integration of several thousand work items, any of which can result in knock-on failure; according to NASA (1986) the loss of the space shuttle Challenger was caused by a failure in the joint between the two lower segments of a motor. Hence maintaining and controlling the scope of work and subtasks deliverables should be subject to agreed quality standards at the early phases of the project.

The level of mega-project instigation and implementation has accelerated dramatically in the twenty-first century between parties that are bound nationally and very often internationally. Between 2013 and projecting into 2030, the market of all mega-project fields is potentially between US$6 and US$9 trillion per year or 8% of the total global gross domestic product(s) (Flyvbjerg 2014). In 2012 spending on industrial mega-projects was expected to be at a rate of $200 billion outside of China, excluding the power generation sector (Merrow 2011). The Middle East is one particular region currently experiencing a growth in large scale infrastructure and engineering mega- projects; opportunities exist, as a result of mega-project growth, to assess the extent to which traditional project management methodologies, systems, processes, approaches and tools might seek to enhance the realisation of projects' preplanning phase(s) in the growth area of the Middle East. The balance of the key factors of scope, quality, cost and time have been recorded by many (as above) to be less than optimum of late; thus more advanced review and (re)development of project management techniques to plan and control and measure quality/cost/time is required to cope (better) with the seemingly constant flexibility and change in the projects' scopes-of-works.

1.2.2 Mega-Project initiation phase

Front-end planning is necessary before deciding to start a project or stop it (Williams and Samset 2010). The Project Management Body of Knowledge /PMBOK Guide (PMBOK, 2013) defines an initiation as authorising the project, phases, activities and tasks. Like any traditional engineering project management, mega-projects have the same concepts and characteristics; the only thing that differs, theoretically, is the size of the project. However the role of the front-end phase in ensuring project success is particularly crucial in mega-projects (Merrow 2011; Morris 2013). In general the theoretical conception phase or process usually covers the business case, scope of work, objectives, deliverables, resources, milestone plan, cost estimation, risks issues, quality and dependences (Haughey 2010), upon which may be imposed a methodology as an essential set of guidelines or principles that can be tailored to a specific situation (Wideman 2005). There are two main traditional project management methodologies, one of which is (by) the project management institution (PMI) as standard for the American government and American companies, whilst another is PRINCE2 (an acronym for PRojects IN Controlled Environments as a de facto process-based method for effective project management, used extensively by the UK Government). PRINCE2 is widely recognised and used in the private sector, both in the UK and internationally.

PMI was created in 1969 by the Institution of Project Management in order to guide project manager to carry out a successful project and divide the project lifecycle into five phases or processes (PMI 2008). PRINCE2 was created in 1989 by the Central Computer and Telecommunications Agency UK and consisted of 8 phases or processes (as below).

Table 1.1: The difference between PMBOK and PRINCE2 processes

PMBOK	PRINCE2
1- Initiating	1- Starting Up 2- Directing
2- Planning	3- Initiating 4- Planning
3- Executing	5- Controlling a Stage 6- Managing Product Delivery
4- Controlling	6- Managing Product Delivery 7- Directing
5- Closing	8- Closing

Source: Adapted from (Matos and Eurico , PRINCE2 or PMBOK–a question of choice 2013)

While PMBOK identified the project definition as a temporary endeavour undertaken to create a product, service or result, PRINCE2 identified the project definition as a management environment created for the purpose of delivering one or more business products according to a specified business case. Table 1.2 shows the differences between the two theoretical methodologies PMBOK and PRINCE2 Methodologies (source: Lopes and Matosa 2013).

Table 1.2: The difference between PMBOK and PRINCE2 methodologies

PMBOK	PRINCE2
Standard	Method
Descriptive Methodology	Prescriptive Methodology
Process based	Product based

Source: Adapted from (Matos and Eurico , Prince2 or PMBOK–a question of choice 2013)

Table 1.3 shows the differences between the two theoretical methodologies in the conception phase for scope of work (W. H. Thomas 2014).

Table 1.3: The differences between the two methodologies in the initiation phase for scope of work

	PMBOK	PRINCE2	Comments
Initiation	Initiation is taken as the initiation of a project or the authorization to continue into the next phase. It mentions tools and techniques, such as project selection methods, benefit measurement methods mathematical methods and expert judgment –no specific method is offered, just a list of possible sources. The output is a Project Charter.	PRINCE2 tackles this in three areas, project initiation, Managing Stage Boundaries and Directing a Project. Project selection methods equate to the PRINCE2 Project Approach, benefit measurement would be found in the PRINCE2 Business Case and the list of those offering expert judgment would be available to any pm method. The project initiation documentation PID equates to the Project Charter, but is wider in scope, e.g. identifying the whole project management team, not just the Project Manager, including the Project Plan, Business Case, risk evaluation and controls.	PMBOK talks of a Product Description as input to initiation, but this is not the same as a PRINCE2 Product Description. It covers the product characteristics, the relationship between the product and the business need, and the 'form and substance' of the product description may vary.
Project Scope Management	PMI covers the scoping of a project or phase and controlling any changes to that scope.	PRINCE2 covers scoping in both the PID and Work Package.	The PMBOK states that this will cover the tools and techniques required, but the only one covered in any detail is the WBS, and there is no effort to continue from that planning point into the other techniques needed to actually produce a plan
Scope planning	This covers the 'progressive elaboration' of project scope. The inputs are the Product Description, the Project Charter and the initial definition of constraints and assumptions. The outputs are the Scope Statement and Scope Management Plan. The latter describes how scope change will be managed and includes an assessment of the expected stability of the project (how likely to change,	PRINCE2 has this as part of the PID, being Problem Definition. The management of scope change is dealt with in PRINCE2 by change control, whose method is described as part of the Project Quality Plan in the PID. In PRINCE2 an assessment during initiation of the volume of change expected leads to consideration of a Change Authority and Change Budget.	This comes after the Project Charter, whereas PRINCE2 makes it part of the information needed before authorizing the project. One of the tools mentioned by the PMBOK is benefit /cost analysis, although there is no specific output of a Business Case. PMBOK does not enlarge upon the scope management plan to discuss what to do if the assessment shows a large volume of expected changes.

	how frequently and how much)		
Scope definition	This is the subdivision of the major project deliverables into smaller, more manageable components. The outputs are work breakdown structures. PMBOK offers three example templates covering an aircraft system, a software product release and a wastewater treatment plan. The process stops at 'decide if adequate cost and duration estimates can be developed at this level of detail for each deliverable.'	This equates to part of the PRINCE2 Product -based Planning technique, the Product Breakdown Structure, without the quality aspect of writing Product Descriptions or the transfer of the products into a Product Flow Diagram. The Planning process contains much more detail in taking the Product Breakdown Structure through the Product Flow Diagram, estimating, scheduling, risk assessment and writing a narrative.	When describing other types of WBS, PMBOK refers to a PBS, meaning a Project Breakdown Structure, as being 'fundamentally the same as a properly done WBS'.
Scope verification	This is described as 'the process of obtaining formal acceptance of the project scope by the stakeholders'. It refers to the acceptance of the work results, i.e. occurs at the end of a project, rather than agreement at the end of initiation on what is to be done	This is dealt with in more depth by the CP and DP5 processes. PMBOK only has formal acceptance as an output.	There is no mention in the PMBOK process of an End Project Report or a Post Project Review Plan.
Scope change control	This is a very high level view of the need for change control, agreeing and managing scope change.	PRINCE2 has both a change control component, a change control technique, processes (CS3 and CS4) to capture and analyse change requests and a series of processes to obtain decisions on changes and manage their implementation (CS5, CS8, Exception Report, DP4, SB6, Exception Plan and DP3 –Project Board decision on a revised plan)	Both methods include noting lessons learned from changes and setting a new baseline.

Source: Thomas (2014)

All-told there are estimated to be approximately 150 project management methodologies (Gonzalez 2010). Table 1.4 shows different methodologies in different fields of project management and how each methodology is deemed to be not fully effective.

Table 1.4: Methodologies of project management for different tasks

Guidelines	PMBOK	Agile	CCPM
Heavy Management Control	YES	NO	YES
Multitasking allowed	YES	YES	NO
Expert Team Oriented	NO	YES	NO
Open Status Reporting	NO	YES	NO
Continuous Changing Processes	NO	YES	NO
Heavy Risk Management	YES	NO	YES
Hierarchical Structure	YES	NO	YES
Phase Organization	YES	NO	YES

Source: Known project management methodologies Perrin (2008), (CCPaceS 2015) and (PMBOK 2008)

The average study time for (mega) initiation phase or project development phase is 3 years with the total installed cost of facility equal to 1% to 3%, while the implementation phase may be as much as 5 years (Berends 2007). According to the largest oil producing company in the world, 'Saudi Aramco', the industrial mega-project engineering implementation cycle takes five years to become a reality. However, five to eight months is the time for funding cycle, bid period, evaluation and award review. This cycle (Fig 1.1) applies when there's competent project supervision and management of a company's own projects, with full potential to deal with major EPC firms, international vendors for engineered equipment and local/international construction firms; Mega engineering projects success factors are somewhat implicitly centred on final profitability (Fig 1.1).

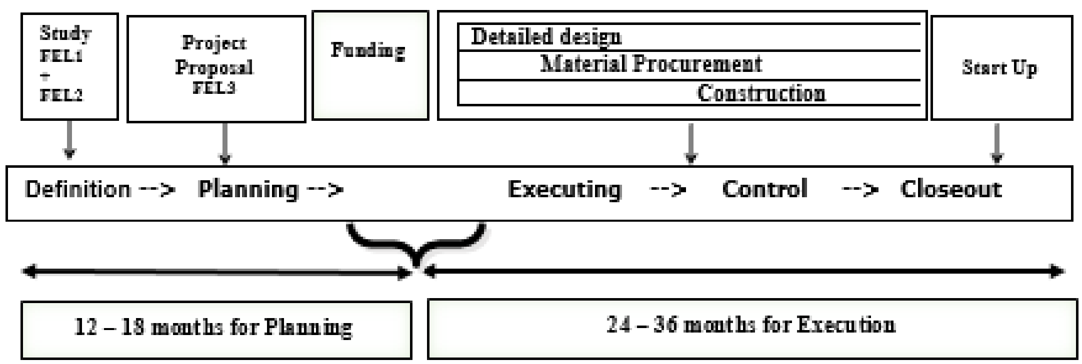


Figure 1.1: Mega-project execution cycle by using LSTK contract. Source: Aramco internal project management standard (2011)

During Front-End-Loading study phase-1, FEL1 and FEL2 or the study phase, the master schedule and milestone schedule are prepared; they cover conceptual design, financial evaluation, budget estimation and contracting strategy. The second stage of the project, FEL3 or project proposal stage, covers milestone schedule and project summary schedule which, in turn, cover definitive scope, estimating tools, expenditure estimation, pro-forma contract, value engineering evaluation, material novation and continuous engineering. The third stage, the project execution and control stage, is needed for project summary and contractor schedule to cover contracts/purchase order, cost and schedule control, construction and pre- commission list, project change request, management reporting and performance monitoring.

1.2.3 Mega-Project management process

Mega-projects can be defined broadly as any activity that has direct or indirect impact on the community, environment and budget and can be stated in monetary terms as being in excess of $1 billion of investment (Altshuler and Luberoff 2003). Again as alluded to above, like any engineering project, mega-projects have the same concepts and characteristics;

It is noted that PMI and PRINCE2 are two main approaches used to manage projects. While the PRINCE2 divides the basic project process into eight; starting up a project, directing a project, start-up planning, directing the planning, controlling executing, managing product delivery for executing and controlling and finally closing a project, PMI divides the basic project process into five processes; initiation process, planning process, executing process, monitoring and controlling process, and closing process.

Regardless of the methodology and terminology used, (mega) project management in different industry fields uses the same basic process or concept. Ende and Marrewijk, (2013) stated that a mega-project's process contains project phase transitions and milestones which connect, by providing spatial and temporal platforms, the interests of project actors, interest groups and constructors. According to PMBOK, during the (mega) project initiation phase, the project team tries to answer the question, "What are we trying to do?" in order to consider the business case, scope and deliverables, objectives, resources needed, milestone plan and timeline, cost estimate, risks and issues.

Large scale (mega) projects usually involve firms from different countries and engineering fields including contractors, suppliers and fabricators. Some companies use the PM process, others use the PRINCE2 process and yet others improve their own process. Kelly, Ledwith and Turner (2010) stated that the nature of small and medium companies' project management is different from the traditional forms of larger companies' project management. They stated that small and medium companies often encounter difficulties with scope of work.

Whyte (2014) found that the project deficiencies are very much a factor of 'process' and 'leadership' - 43% and 38% respectively; unknown internal factors and unknown external factors deemed to contribute 11% and 5% respectively. The Construction Industry Institute (2015) suggests that a sound process at the initiation phase or pre-planning phase can reduce project cost by 20%, decrease overall project schedule and better meet project goals. Morris (2011,7) stated 'It is evident from an extensive amount of research that management of the front-end definitional stages of projects is of overwhelming importance to their ultimate outcome, yet we have little empirical data to suggest how best management competencies here should be improved'.

Gibson and Hamilton (1994) studied 53 capital facility projects and found that a high level of project preplanning can save 20% of project cost and 39% of project time. They concluded that success of project lifecycle phases depends on scope definition at the preplanning phase. It might be argued that improvement of mega-project performance in the construction and engineering fields might begin at the preplanning phase and specifically scope-passing between detailed plans that incorporate flexibility or agility in implementation; before that, however, comes selection of an appropriate project management process to facilitate the daily communication among the project key players.

1.2.4 Issues in the managing of Mega-Projects

The larger the size of the project, (anecdotally) the more it needs experienced project management and construction firms with the ability to handle different engineering disciplines to carry out multi-tasks and to minimize the change order and scope-change. The larger the size of the mega-project, the more it needs precise coordination of the resources and tasks. The clarity of project objectives and how to achieve them are the principle project requirements that need to be delivered to the stakeholders. The length of preplanning and implementation periods of (mega) projects drains budget, time and efforts and leads to continuous change of project scope, for example as a result of design deficiencies. However, the average study time for (mega) initiation phase or project development phase, as mentioned above is, 3 years with the total installed cost of facility equal to 1% to 3%, while the implementation phase may be as much as 5 years (Berends 2007). Therefore, when the cost of change increases during the project phases, the opportunity for the decision makers to influence and change the scope of work of tasks and activities becomes less because the budget has already been assigned. Scope then becomes important.

The Project Management Institute (PMI) defines scope as ‘work that needs to be accomplished to deliver a product, service, or result with the specified features and functions’ (PMBOK guide, 104). Scope is work oriented to using questions that begin with how the work will be done and how costs and schedules will be managed. Scope-change is a status inherent in all projects, generally, and in particular large scale multi-disciplinary mega-projects from pre-planning to delivery and start-up phases due to the high degree of specialist input and need for expert consultations, and this leads to the need for effective coordination and control and sound technical and non-technical input across all project stakeholders. Cho and Gibson (2001) found that poor definition of project scope by owner and contractor organizations led to poor project design and was considered as one of the main causes of project failure.

Ramabodu and Verster (2013) identified critical factors that cause cost overruns in projects as changes in scope of work, incomplete design at the time of tender, additional works, lack of cost planning and monitoring of funds, contractual extension time and delays in costing variations. Lawrence (2008) found that a cost estimator prepares cost estimation report based on the scope of work documents at the preplanning phase and any undefined tasks and activities will carry greater risk than clearly defined tasks and activities. He found that the decision maker needs a good knowledge of the scope definition or alternative ways to measure the scope definition.

Another study related to the issue of scope change was conducted by Zou et al. (2007) and identified factors that influence project delivery: inadequate program scheduling, unsuitable program planning, tight project schedule, incomplete documents and approval, design variations, excessive approval procedures in administrative government departments. In 2008 the Australian Constructors Association and Black Dawson commercial law firm published a report with the finding that, with regard to public and private Australian construction and infrastructure projects ‘the industry practice in relation to the scoping of big scale projects was often seriously inadequate’ (p.4) and they added that ‘managing parties’ disputes related to scoping after signing the contract is an issue’ (p.32).

The measurement and monitoring of quality, cost and time, the key factors of project management, are made increasingly difficult by seemingly constant changes in the general scope-of-works and related deviations from the initial brief; mega-project variation-tracking creates huge complications despite a raft of contract clauses seeking to regulate explicit extensions related to a scope change (Whyte 2014). The Construction Industry Institute (2015) stressed the importance of understanding and embracing the pre-planning process by owners and industry participants. Therefore, it is clear that scope is still a major issue in engineering project management especially when there is no change control in the project. Beyond scope, stage remains of interest.

1.2.5 Stage-gate project management process

Most of the multinational engineering corporations have different approaches toward executing megaprojects. While some follow the American engineering process and standards, PMI, others use the British way, PRINCE2 to implement the projects; problems occur when different interests and companies meet in a mega-project. The owner of the megaproject, such as governments and large national companies that have their own standard and project management teams, tends to face less construction risk during the project preparation, initiation phase and project life cycle. However, individual owners, small-sized-companies, medium-sized companies and also operation companies that do not have their own standards nor a project team to manage and implement (mega) projects may have increased costs of projects. Kelly, Ledwith and Turner (2010) stated that projects in smaller and medium companies are managed by people for whom project management is not their main skill. Andersen et al. (2009) showed, when a small or medium company is run by a parent organization, the parent organization can affect, usually negatively, the way projects are carried out, and the adopted project management processes.

Currently most best-practice companies have implemented the Stage-Gate Process (Cooper , Edgett and Kleinschmidt 2002). Companies such as P&G and ITT in the manufacturing industry, Exxon in the oil and gas industry, Emerson electronics in the IT industry, NASA and other international companies in marketing and design industries are using and are improving the efficiency of the 21th century Stage-Gate Process (Cooper 2008). According to the Construction Industry Institute (2012), most corporations around the world have been recently using the Stage-Gate Process, also called Front End Planning, the phase-gate, front end loading, programming/schematic design, and early project planning to execute the initiation phase or pre-planning phase.

A Stage-Gate Process is a ‘conceptual and operational map for moving new projects from concept to a new product development process in order to improve effectiveness and efficiency’ (Cooper 2008, 216). The Construction Industry Institute (2012) defined the Front End Planning as ‘the process of developing sufficient strategic information with which owners can address risk and make decisions to commit resources in order to maximize the potential for a successful project’ (p. 1.01-1). The Stage-Gate Process is considered as a scalable and flexible risk management model that is used in the pre-planning stage of small projects and mega-projects in order to reduce the impact of technical and business uncertainties through different stages and to reduce the time taken for senior approval (Cooper, Edgett and Kleinschmidt 2002). According to Cooper et al., the Stage-Gate Process suits very different types and risk levels of projects as well as the project management method applied within the Stage-Gate Process; also the Stage Gate Process helps decision makers and project teams to manage resources and decisions if the process is provided with accurate and correct information from the pre-planning phase and final approval of each stage (gate-keeper) is clearly defined to avoid bureaucracy.

Stakeholders of a project need to exercise the maximum collective influence during the pre-planning phase. After each stage, a gate keeper or decision maker who represents a competent authority is responsible for the approval of each phase with the financial authority. Figure 1.2 shows the Stages and Gates of the Stage-Gate Process:

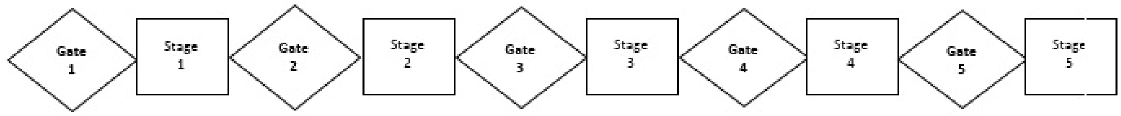


Figure 1.2: Stages-and Grates of Stage-Gate Process. Source: adapted from Stage-Gate® website

Table 1.5 shows current industrial Stage-Gate Phases and Gate review (Gate-Keeper) for the project life cycle for one of the largest Petrochemical companies in the world (SABIC).

Table 1.5: Stage-Gate lifecycle and Gate-Keepers in current industrial project

Stage Gate phases	Gate review/gatekeeper
Initiation and Pre-Feasibility	Project sponsor/Board/VP/GM/Planning/E&PM
Feasibility (Major Milestone)	Project sponsor/Board/VP/GM/Planning/E&PM
Project strategy	Project sponsor/Board/VP/GM/Planning/E&PM
Execution plan	Project sponsor/Board/VP/GM/Planning/E&PM
Design basis	Project sponsor//Board/VP/GM/Planning/E&PM
Basic design & appropriations	Project sponsor/Board/VP/GM/Planning/E&PM
Detailed design & construction	Project sponsor/Board/VP/GM/Planning/E&PM
Closeout stage and reappraisal	The competent authority of the owner

Source: SABIC internal project management standard (2012)

The Construction Industry Institute (2012) defined the Front-End Loading or FEL or Stage-Gate process as 'the process of developing sufficient strategic information with which owners can address risk and make decisions to commit resources in order to maximize the potential for a successful project' (P. 1.01-1). Merrow (2011) defined the front end loading FEL or Stage-Gate process as 'the core work process of project teams prior to authorization and the work process. The work process is typically divided into phases or stages with a pause for an assessment and decision about whether to proceed' (p. 202). The concept of Stage-Gate process and FEL is the same but the names of the phases and stages are different in each of the industrial fields of oil and gas projects, petrochemicals and mining projects and this may have an effect on quality of communication between mega-project parties, contractors and sub-contractors. Table 1.6 shows the current industrial stages of FEL and the name of each phase (Merrow 2011):

Table 1.6: Current industrial phases and name of each phase and cost (Merrow 2011)

Mega-Projects	FEL1 (Apprise opportunity)	FEL2 (Develop scope)	FEL3 (Define project)
Mining	Concept study or idea definition	Prefeasibility study	Feasibility study
Petrochemical	Business planning	Facilities planning	Execution planning
Oil & Gas	Appraise	Select	FEED Front End Engineering Development
Cost			Very expensive for megaprojects

Source: Current industrial phases and name of each phase (Merrow 2011)

Merrow (2011) observed that the current industrial mega-projects in project management have six phases, two for FEL1, one for FEL2, one for FEL3, one for execution and one for produce. and three Stage-Gate keepers for decision and review and could be five Stage-Gate keepers (Figure 1.2) while the Construction Industry Institute (2012) divided the FEL or Stage-Gate at the pre-planning phase into three stages which are feasibility, concepts and details scope and under each phase there is a theoretical detailed process. Figure 1.3 shows a basic version of the Stage-Gate process which covers the business case, scope and readiness before project execution and it includes team dynamics, technology selection and plan, site factors, design statue and 3D-Model, and project execution strategy (Merrow 2011).

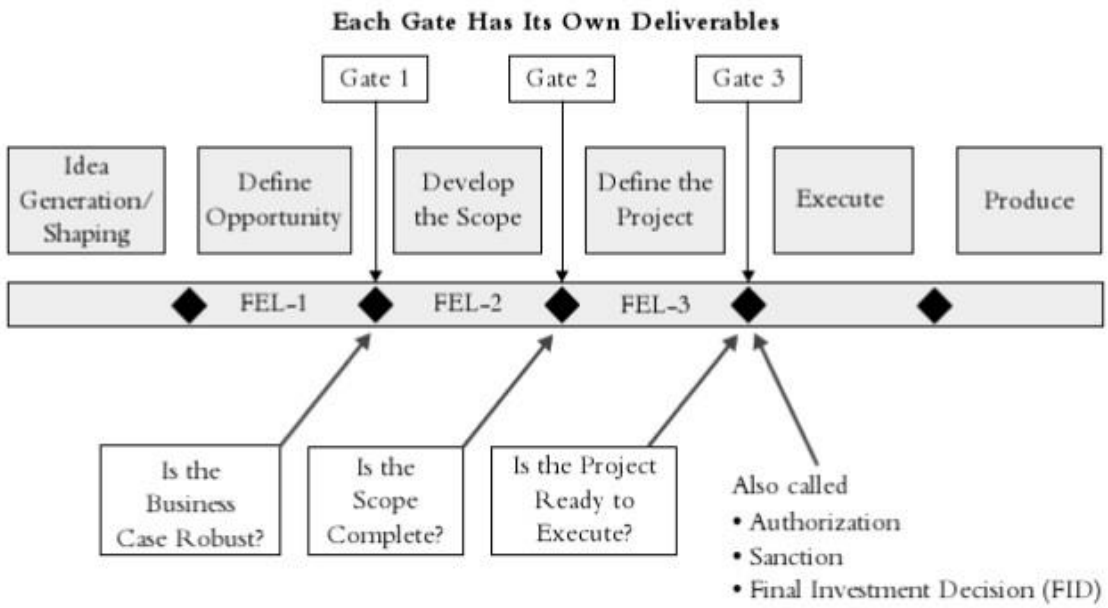


Figure 1.3: Industrial basic Stage-Gate process, Eduard Merrow (2011)

For an accurate and well defined project proposal, the first phase in the Stage-Gate process to begin the project with is the project definition in order to study the techno-economic and project business strategy. Prefeasibility and feasibility stages are a review and assessment for project feature, options and risks related to technical, logistical and economic parameters of the project in order to test if it lies within the project's predetermined acceptance limits and boundary. The legal entity and/or the owner is responsible for the planning including procedure and practices for research and technology, corporate strategy and operation. Broad technical scope, project objective and project strategy would be considered during the design basis phase of the project strategy and execution plan. The next phase is the procedures and practices of the project scope, project execution plan and financial commitment. The last phase of the Stage-Gate process, before implementing the execution phase, is the project delivery and closeout which contains project specification, budget and schedule. Figure 1.4 shows the theoretical Stage-Gate planning process at the pre-planning phase adapted from the Construction Industry Institute (2012).

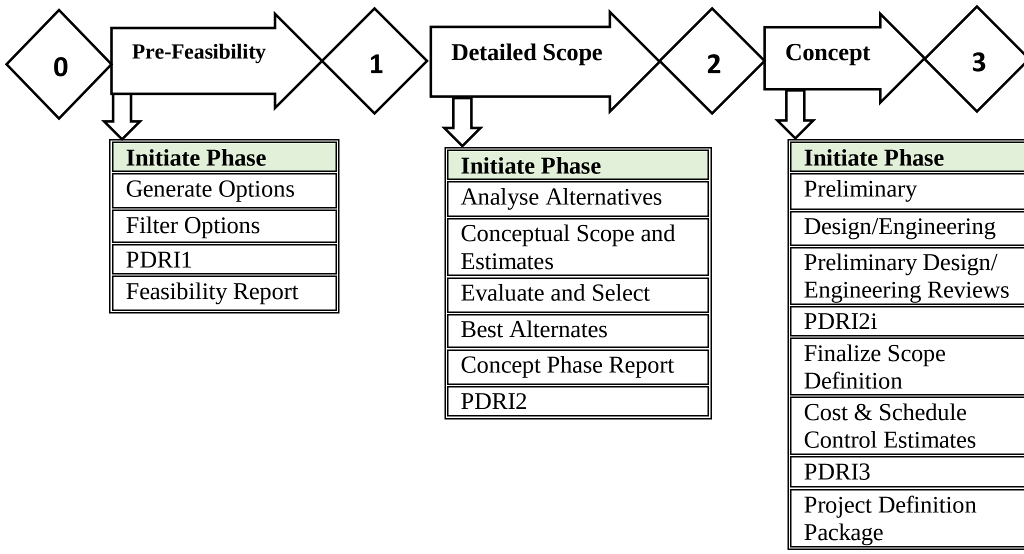


Figure 1.4: Theoretical Stage-Gate planning process at preplanning phase adapted from the Construction Industry Institute (2012)

However the modern Stage-Gate system is not always effective and benchmarking studies have revealed that many companies have struggled with the concept, have missed key facets, principles and methods in the system (Cooper 2008). Wittig (2014) found that the current mega mining project practices require an integrated framework for Stage-Gate phases through project development to reduce cost and schedule overrun. Cooper (2014) wrote Journal article based on several studies under the title ‘What next after Stage-Gate?’ and the aim of this article to look at what leading firms are doing to move beyond their current Process (Idea-to-Lunch) and to integrate these practices into a next generation. He listed 25 points to compare traditional Stage-Gate with next generation system and found that no one company has implemented the whole 25 elements yet in order to move the next generation system of Stage-Gate. He stated that the next-generation of Stage-Gate systems is to accelerate projects and some leading companies are working to fast track a version of Stage-Gate. Regard learning from experience report, Jordan et al. (1988) argued that 15% of the time and resources in projects should be spent on front-end work, whereas Miller and Lessard (2001) suggested up to 35% of time and money must allocated on pre-planning phase. Of next immediate concern for managers beyond stage is scope/scope-change.

1.2.6 Scope and scope changing for mega-projects

Project Management Institute PMBOK defines scope as ‘the sum of the products, services, and results to be provided as project’ (p. 561). PMBOK defined the scope change as ‘any change to the project scope. A scope change almost always requires an adjustment to the project cost and schedule. (p. 561). Scope creep also is defined by PMBOK as ‘the uncontrolled expansion to product or project scope without adjustments to time, cost and resources (p. 561).

The U.S. National Cooperative Highway Research Program (NCHRP-Report 574) is well-designed research and provides an effective approach to the solution of many problems facing highway engineers and administrators in a published guidebook; Guidance for Cost Estimation and Management for Highway Projects during Planning, Programming and Preconstruction by Anderson et al. (2006) towards presenting approaches to cost estimation and management to overcome the root causes of cost escalation. This document seeks to support the development of consistent and accurate project estimates through all phases of the development process; NCHRP found that focusing early on internal factors of project scope will reduce project cost growth at bid time or during construction.

The Australian constructor association identified steps for successful scoping for infrastructure big scale projects as shown in Table 1.7.

Table 1.7: Steps of successful scoping for big scale projects adopted from the Australian constructor association (2008, 6)

A- Clarity of project objective and requirement:

- Identify the stakeholders and end users;
- Identify project objectives and requirement by hold a workshop that brings all together the relevant stakeholders and end users;
- Determine the scope needs by setting realistic timeframes and budgets;
- Understand of project interfacing with other related project and existing infrastructure;
- Minimize delay if changes to the project occur, project assessment and approval process should be presented;
- Identify and establish the core project team with experience and ability to manage process;
- Empower the project leader with the clear and appropriate authority and accountability.

B- Clear contract Scope:

- Choose appropriate contract delivery method and match method with level of scope prescription;
- Understand prescriptive scope and role of performance then chose appropriate approach;
- Set realistic timeframe to prepare project scope, using an experienced and able project team;
- Check contract package as a whole for consistency prior to tender or contract to avoid or minimize the incomplete, uncoordinated and inaccurate scope document.
- Consulate with tenderer in providing feedback on project scope;
- Obtain site information for better determining requirements for project scope.
- Capture the value from the successful tenderer's bid in final contract scope.

Source: The Australian constructor association (2008, 6)

However, even with all of these efforts, scope change is still a major issue in engineering project management especially when there is no scope change control in the project defined by PMBOK as ‘ the process of monitoring the status of the project and product scope and managing changes to the scope baseline’ (p. 135). Any poor preparation for project scope during the pre-planning phase may lead to scope creep that could cause cost overrun.

In Stage-Gate process or Front-End Loading, the scope and reliability of cost estimation are developed in FEL2 for FEL3 and the whole project hangs heavily on completeness of scope developed in FEL2. Merrow (2011) pointed out that ‘one characteristic of front-end development work is the schedules tend to be rather fluid. It is in the nature of scope development to be iterative and therefore hard to precisely schedule’ (p. 177).

Aligned with scope becomes contract that seeks to pin-down the obligations and responsibilities of scope.

1.2.7 Scope changing and contract

PMIBOK defined contract as ‘a mutually binding agreement that obligates the seller to provide the specified product or service or result and obligates the buyer to pay for it (p. 532). It added that contracts are divided into fixed-prices or lump sum contracts, cost-reimbursable contracts, time and material contract. Contract (procurement route) is the corner stone and an important element for project control and lifecycle since it shapes the behaviour of the project participants. The contract should define simply and clearly scope and scope of work in the form of the legal, financial and technical aspects of the project and the rights of the large number of megaproject stakeholders. Lately conflicts of interests between the project’s parties have become a main issue, while the role of project owner/sponsor/client is to shape the business driver and the concept of project partnership/or joint venture with technology provider/designer/constructor and contractors.

There are different types of contracts and no specific type of contract for mega-projects or heavy projects simply because every project is unique in time and place. However, contract strategy and success for any project depends on the capabilities of the owner/sponsor, the nature of the project and engineering, procurement and construction market. Most engineering mega-projects, specifically in oil and gas, chemicals and mining, have become confined to limited global corporations and technology owners who drive the market not the contracts. While some countries and contractors of the Organisation for Economic Co-operation and Development (OECD) such as EU adopt Alliances contracts, countries such as the Middle East, Africa, Asia, and South America use EPC (engineer/procure/construct) Lump Sum and EPC Lump Sum Turnkey (Merrow 2011). Most mega-engineering projects around the world are in the hands of government or in the hands of nationally based firms but the technology owners are the major drivers for the project lifecycle.

Contractor and market knowledge are also factors related to achieving a successful on-time and on-budget project. Carr (1989) found that, in the UK, tendering for work in an area which contractors had little knowledge of is also a significant reason leading to project inaccurate estimating. Akintoye and Fitzgerald (2000) found that the major causes of inaccurate project cost estimation at the early phases in the UK were insufficient time for tender preparation; poor tender documentation; insufficient analysis of the documentation by the estimating team. Therefore UK contractors sometimes form joint ventures with home-based contractor/owner when they tender for work overseas (Potts and Ankrah 2013). The U.S. and other international companies likewise form joint ventures when tendering for work in Saudi Arabia (public, private, and semi-private companies). Some Saudi companies have the ability to manage the projects, others hand the project planning and activities over to the main contractor who may lack knowledge of the local market. Scope of work ambiguity of mega-project at the scope development FEL2 stage is one serious engineering mega-projects issue, thus (cost reimbursement) contract requires presentation at this stage.

Due to the lack of project management team and in order to transfer the risk into contractor (s), some engineering oil and gas, petrochemicals, and mining companies assign a mega-project contract by EPC and EPCM contracts or both including Lump sum turnkey (LSTK).

The EPC contract is usually priced by using fixed price method whereas the EPCM uses the cost reimbursable method (Sink 2009). According to Merrow (2011), Engineering Procurement Construction (EPC) lump-sum contracts are the most common form of mega-project and if the commissioning and start-up are included in the contract then it becomes Turn-Key. EPC is a contracting approach in which a prime contractor is responsible for delivering the complete project to the owner/sponsor who needs to ‘turn a key’ to start the operation. While the cost of EPC contracts is higher than EPCM, EPC project time is shorter than EPCM and the contractor incurs most of the project risk (Lampe 2001).

Although EPC Lump-Sum is the predominant contractual method around the world, some corporations or governments are using hybrid EPC/EPCM reimbursable for engineering mega-projects. According to the oil and gas industry, Aramco has the world's largest proven crude oil reserves and largest daily oil production; one of the best current contractual method strategy to meet mega-project challenge is a combination of Reimbursable/Lump Sum. However, this contractual method needs a relatively knowledgeable owner/client. Berends (2007) stated that the cost reimbursable type of contract is being used by the owners of oil and gas mega-projects for the project development phase in many countries around the world, government control contracting process and require low bids (traditional contract) to be accepted for public projects. 'Acceptance of significantly low bids (of mega-projects) almost always triggers project failure' (Merrow 2011, 272). Figure 1.5 shows the difference between the traditional contract and Turn Lump Sum Key contract (LSTK) for industrial mega-projects with regard to the bidding of procurement and construction. In the traditional contract the bid for procurement starts after finalizing engineering details, while in current industrial mega-projects, procurement bidding starts in the middle stages of engineering stage (FEL1 and FEL2) and also the construction bidding starts at the middle of the procurement stage in order to speed up project process.

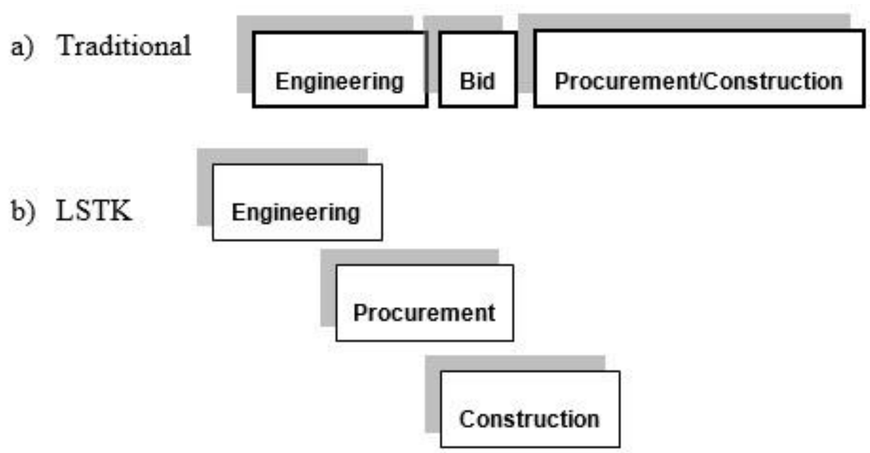


Figure 1.5: The difference between industrial mega-project contracts adopted from Aramco internal project management standard (2011)

While a contract has an inverse relationship with cost control through contract strategy and pricing format, the contract relationship with scheduling represents tender and award schedule. Moreover, the contract relationship with the planning department is contract packaging and bid sequence (See Figure 1.6 adapted from Aramco internal standard.

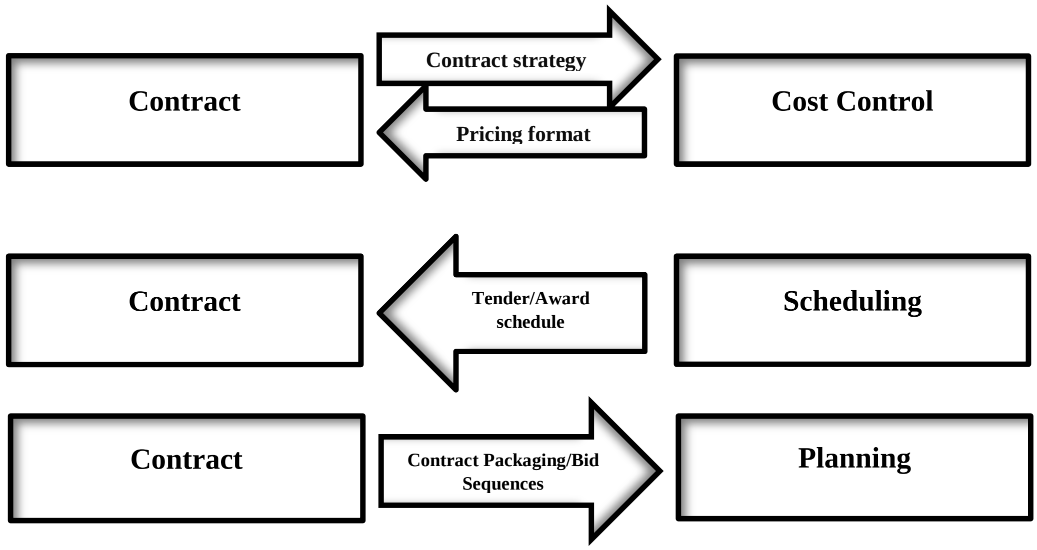


Figure 1.6: Contract and cost control for megaproject adapted from Aramco internal project management standard

Sinnette (2004) discussed the importance of estimates in establishing accurate performance expectations at each step of the mega-project's development in U.S., he suggested steps to improve large scale project cost estimation of packaging the contracts, he stated that 'extremely large construction packages also have the potential to reduce the number of contractors capable of bidding and may need to be broken up into smaller contracts to attract additional competition.'. Sinnette (2004) also suggested that 'perform a value analysis to determine the most economical and advantageous way of packaging the contracts for advertisement' (p. 40-47).

To conclude, a mega-project involves many different types of contracts during the project lifecycle such management, engineering, design, procurements, construction, commissioning, start-up, maintenance and operation. Choosing an appropriate contract strategy for each phase and stage of mega-project starting of the preplanning phase and is still considered a (somewhat complex) business management task due to owner/client contract management strategy of mega-projects that drives by time of achieving the phase/task/activity/project.

1.3 Research Aim, Objectives and Scope

1.3.1 Research aim

The main aim of this research was to evaluate the mega-project management process being applied in two (mega) projects at the project development phase and construction phase. In the work the medium-sized organization, the focus of this research study, had experienced overrun(s) of two mega-projects with regard to budget, time and resources during the preparation phase/ prefeasibility /feasibility/execution/start-up phases, and had faced also many uncertainties during the course of the project lifecycle which had caused many change orders during the basic design /detailed design /procurement /construction /operation phases. There are many issues in mega-project management such as two international traditional systems for a mega-projects at the early preplanning phase, traditional contracting and procurement systems, scope-change and scope creep which is resulting in a waste of project resources and time. This research study therefore was designed to clarify the processes used on the two mega-projects especially at the preplanning phase in order to recommend improvements to the project lifecycle process for future projects.

1.3.2 Research objective

This particular research was designed to evaluate the project management processes used in two mega-projects in Saudi Arabia in order to devise an improved project management process framework for the mega-project preplanning, initiation, prefeasibility, feasibility, and construction, delivery and start-up phases as well. This primary aim can be broken down further into a number of key objectives. Table 1.8 shows the specific objectives of this research and the methodology used.

Research.

Table 1.8: Research objectives and methodology approaches

Objective	Methodology
Determine the process used in the early stages of the two Mega-projects;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 5, Question 10, Question 19, Question 23, Question 28, Question 30 ,Question 39,Question 44, Question 51, Question 58, Question 59 , Question 62, Question 65 and Question 78.
Identify the measures used for the Mega-projects at the early stages to avoid project life cycle problems and to speed up implementation of project activities without compromising the quality of work and project;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 15 and Question 39.
Determine the factors impeding the effectiveness of the measures;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 9, Question 22, Question 46, Question 47 and Question 78.
Determine the personnel's knowledge in relation to technical tasks;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 16, question 17, Question 18 and Question 19.
Ascertain the adequacy of training in the process used;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 21, Question 72 and Question 78.
Determine how scope of work, scope change and scope creep were mitigated; Determine the type and effectiveness of the Mega-projects' contracts;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 3, Question 4, Question 12, Question 13 and Question 24. Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 20, Question 45, Question 46, Question 47, Question 48, Question 49, Question 50, Question 51, Question 52, Question 53, Question 54, Question 55 and Question 56.

Determine the internal and external factors affecting the effectiveness of the Mega-projects' contracts	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 8, Question 45, Question 46, Question 47, Question 48, Question 49, Question 50, Question 51, Question 52, Question 53, Question 54, Question 55 and Question 56.
Establish the evaluation techniques used on the Mega-projects and their effectiveness;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 38, Question 39, Question 40, Question 41, Question 42, Question 43, Question 44, Question 45, Question 46, Question 47, Question 48, Question 49, Question 50, Question 51, Question 52, Question 53, Question 54, Question 55 and Question 56, Question 57, Question 58, Question 59, Question 60, Question 61, Question 62, Question, 63, Question 64, Question 65, Question 66, Question 67 and Question 68.
Determine the internal and external factors affecting the effectiveness of the evaluation techniques;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 2, Question 38, Question 39, Question 40, Question 41, Question 42, Question 43, Question 44, Question 45, Question 46, Question 47, Question 48, Question 49, Question 50, Question 51, Question 52, Question 53, Question 54, Question 55 and Question 56, Question 57, Question 58, Question 59, Question 60, Question 61, Question 62, Question, 63, Question 64, Question 65, Question 66, Question 67 and Question 68.
Establish how risk was assessed and monitored during the pre-planning and construction phases;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 48, Question 49, Question 50, Question 51, Question 52, Question 53, Question 54.
Establish to what extent technology and software were used and how effective they were in all of the lifecycle stages;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 30, Question 31, Question 32, Question 33, Question 34, Question 35, Question 36, Question 37, Question 38, Question 39, Question 40, Question 41 and Question 42.
Evaluate the performance of the design teams from pre-planning through to feasibility stages;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 14, Question 69, Question 70, Question 71, Question 72, Question 73, Question 74, Question 75, Question 76 and Question 77.
Determine the factors affecting the performance of the design teams from pre-planning through to feasibility stages;	Qualitative- semi structure face to face interview and documents for the following questions, refer to Section 4.2; Question 11, Question 14, Question 28, Question 69, Question 70, , Question 71, Question 72,

	Question 73, Question 74, Question 75, Question 76 and Question 77.
Determine the function analysis techniques used and their effectiveness;	Qualitative- semi structure face to face interview documents for the following questions, refer to Section 4.2; Question 69, Question 70, , Question 71, Question 72, Question 73, Question 74, Question 75, Question 76 , Question 77, Question 78, Question 79, Question 80, Question 81, Question 82, Question 83 and Question 84.
Establish which factors impeded the effectiveness of the function analysis.	Qualitative- semi structure face to face interview documents for the following questions, refer to Section 4.2; Question 80, Question 82, Question 83, and Question 84

1.4 Scope of the Research

The scope of this particular research was designed to evaluate the project management processes used in two mega-projects in Saudi Arabia in order to devise an improved project management process framework for the mega-project preplanning, initiation, prefeasibility, feasibility, and construction, delivery and start-up phases. The study focuses on activities, practices and processes of executives, managers and main contractors, managers' during project lifecycle and starting of preplanning phase. The scope of the study is limited to CEOs, VPs, executives and higher management within this Saudi 'operation' mining company and two subsidiaries that had worked for the two mega-projects during the preplanning phase. A series of in-depth interviews were conducted over three months with participants who had been involved with the planning and delivery of mega-project at the preplanning phase in order to obtain an in-depth understanding of the key issues at this critical stage.

1.5 Significance of the Study and Research Contributions

There is a need to address the process and techniques of project management and its implementation, as preplanning project management teams strive to deliver a quality product at a predicted cost, within a set timescale for engineering and construction. It might be suggested that project engineers and design teams, generally, are failing clients if they are unable to deliver what they have been requested to do (a suitable realisation of the project brief), within an agreed budget and an accurate timeframe. ‘Although there are no articles addressing comparative analysis of time delays in large projects, there is a strong relation between delays and cost overrun’ (Giezen 2012, 782). A number of benefits will be gained from this research project. These benefits will take the form of both theoretical benefits and benefits to industry.

1.5.1 Theoretical benefits

The contribution of this research study of preplanning phase of two megaprojects for the same operation company, under different managements and different main contractors can boost understanding of the mega-project preplanning process phase in the fields of academia since many project management in the field of academia have lack the holistic view and understanding of mega-projects project process starting from preplanning phase; this research study was designed to assess, clarify and evaluate mega-projects processes in order to help to reduce the scope change and scope creep starting from the preplanning phase.

1.5.2 Benefits to industry

The results of this research are expected to have a number of significant benefits to the construction industry. These include the ability to:

- Many project management practitioners, engineers, technicians and developers of software engineering tools have lack the holistic view and understanding of mega-projects project process starting from preplanning phase;
- Enhance understandings among shareholders, stakeholders, departments and individuals will lead to shortened preparation time for the implementation phase of a mega project; specifically tasks at each stage should be finished in a shorter time with high quality and on budget; change orders and scope of works will be minimized;
- Improve project performance starting of preplanning phase and passing by design phase until the start-up phase;
- Reduce the ambiguity of Mega-project process at the preplanning phase for professional and individual staff;
- Improve communication, enhance cooperation and enthusiasm among the project parties and also it may help to minimize the number of change orders and scope creep possibilities;
- This may also lead to Mega-project time and budget savings at the early stages and during the project lifecycle in general.

In order to overcome many of the previously highlighted difficulties, the outcome of this research study was the development of a mega-project road map and hybrid stage-gate process for future preplanning phases.

1.6 Research Approach and Design

Two case studies for two mega-projects are applied and data were collected from CEOs, VPs and executives, directors', managers, of the two subsidiaries and one project main partner. Case studies of this kind can help the researcher to understand the approaches taken by top management when implementing mega-projects at the preplanning phase. Unbiased data collection approaches adopted / supported for the main source of information Government and CEOs'. Eighty four questions divided into six categories and different approaches. The research questions are derived from the research literature, but they could come from current business practice or your initiative hunches (Marshall and Rossman 1989).

1.7 Thesis Overview

This research thesis comprises seven chapters:

Chapter 1: Introduction and background.

Chapter 2: Literature review related to the research topic and questions.

Chapter 3: Methodology and research design.

Chapter 4: Results of interviews.

Chapter 5: Discussion of results.

Chapter 6: Study outcome: Mega-project preplanning phase road map

Chapter 7: Conclusions and recommendations

1.8 Chapter Conclusion

The chapter provided a background and statement of megaproject problem, namely, cost overrun, delay of time during the preplanning phase, construction phase, and start-up phase, quality issues for small and medium companies that intend to build high quality mega-projects, scope changes, scope creep, stage-gate process/FEL, contract issues and lack the holistic view and understanding of mega-projects project process at preplanning phase by practitioners and academics. Having introduced the mega-project orientation of this study related to project management tools and techniques, and the need for (re)development of these towards improved processes, the following chapter provides a more expansive literature review of planning, organizing, controlling, monitoring and feeding-back information to better address resourcing of projects.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview and analysis of megaproject management research and associated issues of mega-engineering projects at the preplanning phase including traditional project management system, process, scope of work and traditional contracting. Specifically this chapter is devoted to the research examining the preparation of mega-engineering scale projects, and consists of four parts.

The first section shows a number of sub questions were considered by this research of industrial mega-engineering project for preplanning phase.

The second section covers planning, cost overrun, and delay of schedule, and quality issues starting from the preplanning phase.

The Third section analyses studies on traditional mega-project methodologies used during mega-project life cycle, issues, their advantages and disadvantages.

The forth section introduces the traditional Stage-Gate Process for the mega-project lifecycle and planning.

The last section discusses the ongoing issues for projects in general including intervention of scope, scope change, scope creep in relation to project lifecycle, success factors and obstacles and mega-project contractual issues.

2.2 Study Objective

This study was designed to evaluate the project management processes used in two mega-projects in Saudi Arabia in order to devise an improved project management process framework for the mega-project preplanning, initiation, prefeasibility, feasibility, and construction, delivery and start-up phases as well. This primary aim can be broken down further into a number of key objectives. The specific objectives of this research were;

1- Determine the process used in the early stages of the two megaprojects;
2- Identify the measures used for the (mega)-projects at the early stages to avoid project life cycle problems and to speed up implementation of project activities without compromising the quality of work and project;
3- Determine the factors impeding the effectiveness of the measures;
4- Determine the personnel's knowledge in relation to technical tasks;
5- Ascertain the adequacy of training in the process used;
6- Determine how scope of work, scope change and scope creep were mitigated;
7- Determine the type and effectiveness of the megaprojects' contracts;

2.3 Study Questions

The questions this study sought to address were:

1- Is there a relationship between project management process, scope creep, value management, contractual arrangement, procurement and software programs generally in terms of speed up project delivery?
2- Are traditional project management process adequately addressing the key variables of "scope" as applied to mega-project?

3- Can current stage-gate project management practices and activities be structured objectively for more efficient realization of mining mega-project briefs?

4- Are any of the constituents of antecedents of stage-gate project management applied in the medium and small scale companies, albeit under the guise of more traditional approaches?

5- Can stage-gate project management practices and activities be structured objectively for a more efficient realization of mega-project briefs?

6- Identify the characteristics of successful mega integrated project for medium mining operation firm that is rich of natural resource and lack of project management team.

7- Is there a relationship between size of the mega-project and project delay?

8- Can mega-project shorten to less stage-gate phases in order to save money, time and effort during the initial stages of the project?

2.4 Data Collection Methodology Approach

The data collection method of this research was collected from different chief executive officers, vice presidents, executives and higher management of the two subsidiaries and a partner of one of the megaprojects mega-project management staff in the mining construction industry and two case-business studies. This was achieved by doing semi-structured face to face interviews in five cities for two case studies of two mega-projects processes and with two subsidiaries that worked under the supervision of the parent company for over three month period. The data collection method includes individual official interviews and documents such as technical and non-technical reports, annual reports, design and drawings documents, specifications, financial information, work activities and tasks, contract agreements, minutes of meetings, internal memoranda, booklets, brochures and journal article and newspaper. Qualitative methodological approach was chosen for this research in order to obtain expert points of view about the events which had affected the course of the two megaprojects starting from the preplanning phase, including the project lifecycle, particularly to examine and evaluate the reasons behind the continuous change orders and scope of work change of both megaprojects. The data collection method of this research was supported by official approvals from the CEOs' of the two subsidiaries, an official letter from the government and the university. A total of 15 in-depth face to face inter-views were undertaken during over three months, and follow up email took place after doing the interviews in order to clarify some of small issues with some participants. The interviews the length varied from 45 minutes to three hours. A guideline for interview questions was provided in Appendix A. It consisted of 84 open-ended questions. Each question, however, was only a point of reference. The researcher began the interviews with questions similar to the questions in the guideline, and then depending upon the responses received, he moved into probing questions. Probing questions were useful in gaining more insights and clarifying the answers from the respondents.

2.5 Existing Research

2.5.1 Mega-project cost overrun, delay of time and quality issues

Flyvbjerg (2007) and Aalborg University in Denmark conducted several studies in 20 European countries, focussing on the development of 258 public-private large transportation infrastructure projects; problems, causes and cures in policy and planning during preplanning phase for 58 rail, 33 bridge and tunnel, 167 roads and found that large scale projects misinformation of costs at the preplanning phase leads to cost overrun, benefits shortfalls and waste. They also found cost overrun on large public-private projects occurred due to underestimation of large scale projects cost at pre planning phase, and it occurred for 9 out of 10 projects throughout Europe for the last 70 years. They focused on a process structure of large scale projects, and presented better improving planning measures. They suggested that large scale public and privet projects at preplanning phase including cost, risk and benefits must be reviewed by an independent external organization. They listed the preplanning phase problems of large scale public-privet projects in the following points;

- Large scale projects preplanning take long time to plan, and it is complex and risky due to the existence of different authorities around projects site (project interface);
- Complexity and advancement of technology complicated the project's design at the preplanning/planning phase (s);
- Personal interests of projects multi-actors decision makers;
- Changing project scope of work over time;
- Unplanned project tasks/activities affect projects budget;
- Shortage of information about the costs and risks at the preplanning/planning phase;
- Most of the projects had cost overrun as a result of the poor planning and misinformation in the preplanning/planning phase.

Flyvbjerg (2008) also re-examined several studies in 20 European countries for a large transport infrastructure projects in order to better predict large scale project performance and to evaluate the large scale project cost overrun and time, and inaccuracy of estimations and forecasts during the preplanning phase, and they found that there were over-estimation of project benefits and success in positive way by owner/clients and also under-estimating of cost and time strategically at the preplanning phase in order to obtain project funding were the two main factors that caused cost overrun and delay of projects.

Another study evaluating a mega-project cost overrun and time to reduce the complexity and uncertainty at the preplanning phase was carried out by Giezen (2012) who used a case study method with interviews in the Netherlands; he found that the costs of mega-projects usually overran because of optimism bias or strategic misrepresentation.

Another study by Marrewijk et al. (2008) conducted 85 and 30 biographical in-depth interview for two public-private mega-projects in Netherlands (infrastructure) and Australia (water tunnel) in order to determine the impact of mega-project culture and management, project design and daily practice on the level of cooperation between partners; they found that project culture and design determine 'project design and project cultures and rationalities play a central role in influencing successful cooperation between partners (p. 599). They added that 'the practical rationalities and practices of the (mega) project players need to be considered' (p. 600). They concluded that the advancement of technology was critical element in design phase and it must be considered at the preplanning phase.

Assaf and Al-Hejji (2006) carried out a study to determine the causes of large construction project delays using a time performance questionnaire survey with 15 owners, 23 contractors and 19 consultants. Their study found 73 causes of project delay in Saudi Arabia and found that the most common cases of delay identified were change order and the owner.

Another large-scale infrastructure (public bridge) project study in the U.S. was undertaken by Frick (2008) in order to evaluate the impact and implications of the complex modern technology on the planning process, project design and implementation (risk association); data collection was through in-depth interviews with 45 key participants in the U.S. and an extensive review of project-related documents and media accounts. She found that the complexity of project influenced design, project outcomes, project fund, and increase project cost overruns.

Another comparative research study conducted by Akintoye (2000), using a survey of 84 UK contractors (small, medium and large) examined the factors contributing to delays and increased costs in construction phase and identified several factors influencing project cost during the (construction phase). These influencing factors represent project size and scope of project, project duration, complexity of design, organization's expectation of project, tender period and market condition, extent of completion of pre-contract design, contractual arrangement and form of procurement, delivery of long lead items, capability and number of the firm team and project team, method of construction, expertise of consultant, site constraints, client’s financial position, buildability and location of the project. He suggested seven factors to be considered by contractors during the construction phase; (1) project complexity, (2) technological requirements, (3) project information, (4) project team requirement, (5) contract requirement, (6) project duration and (7) market requirement.

Zou et al. (2007) conducted a postal questionnaire survey with 60 construction practitioners in Australia to identify and analyse the risks associated with the development of construction projects from project stakeholder and life cycle perspectives and found that 51 risks are able to influence the project objectives or lifecycle; these are related to cost, time, quality and safety starting from tight schedule at preplanning phase and influencing the five phases of project lifecycle including operation phase. The key risks were associated with feasibility, design, construction and operation phases respectively. Zou et al. also highlighted the main 20 related risks to owners, designers, contractors, subcontractors, government authorities/bodies and external environment risks (see Table 2.1). They concluded that owner, project designers and government authorities should work together at the preplanning phase in order to address project potential risks in time and to create value, meeting project tactical and strategic objectives and requirements. Also companies (contractors and subcontractors) with good organizational knowledge management processes (strategy, culture, process, technology, management, corporate politics) must join large scale projects from early phase and cooperate with project teams in order to minimize risks during construction phase.

Table 2.1: The 20 main key risks that influence project objectives (cost, time, quality and safety)

1- Tight project schedule;
2- Inadequate program scheduling;
3- Unsuitable construction program planning;
4- Inadequate or insufficient site information;
5- Lack of coordination between project participants;
6- Occurrence of disputes;
7- High performance/Quality expectation;
8- Incomplete or inaccurate cost estimation;
9- Incomplete approval and other documents;
10- Excessive approval procedures in administrative government departments;
11- Bureaucracy of the government;
12- Design variation;
13- Variation by the clients;
14- Variation of construction program;
15- Unavailability of sufficient professional and managers;
16- Unavailability of sufficient amount of skilled labor;
17- Price inflation of construction materials;
18- Low management competency of subcontractor;
19- General safety accidents occurrence;
20- Serious noise pollution caused by construction.

Source: Zou et al (2006, 7)

In conclusion, this section has shown there are many reasons for cost overrun and mega-project delay. The larger the size and complexity of the project; the more uncertainties and risks in all its form surround it.

2.5.2 Mega-project management approaches

A case study conducted by Matos and Eurico (2013) was designed to determine which of the two main methodologies (PMBOK or PRINCE2) should be applied to information technology project; they found an overlap and gap between these approaches. They concluded that ‘from a point of view of project planning both methodologies (were) similarly, and at the point of project documentation and following up, PMBOK (was) more completed’ (p. 793).

Another study conducted by Morris and Jamieson (2005) and funded by PMI, industry and academia and reviewed evidence from four case studies with questionnaire data from project management Institute-Europe members; their findings showed that the processes, practices, and people issues involved in moving from corporate strategy to programs and projects is done in a systematic way. They found that, in the study phase, project process, practice and people need to be involved in moving ideas to practice at the preplanning phase. The paper concluded that future revisions of the PMBOK Guide should be looked at. They added that ‘project strategy management (was) an underexplored and insufficiently described subject in the business and project literature, it (was) in fact, a relatively well-trodden area, deserving of more recognition, formal study, and discussion’ (p. 6).

Another study carried out by Thomas (2014) to review and compare the advantages and disadvantages of PMI/PMBOK and PRINCE2 certifications/certificate concluded that

PMBOK did not cover pre-project process and only provided scant advice, while PRINCE2 showed what or who should be in place at the beginning of a project. He added that the PMBOK covered the actual procurement, pre-assignment or negotiation for team members for a project in some detail, needs of human resource management and only considered the project plan, while PRINCE2 covered a complete change control approach, offers stage and team plans and discussed the advantages of breaking the project plan down.

A master - thesis study conducted by Al Matari (2014) aimed to combine PRINCE2 and PMBOK in a single methodology; he concluded that both PRINCE2 and PMBOK should be ‘tailored’.

In conclusion, this section (alongside earlier ‘Background’ discussions) highlight the advantages and disadvantages of the two main project engineering approaches, PMBOK and PRINCE2, as well as the difference between the two widely used professional certificates of project management in order to develop a project from idea to product. Both traditional approaches can be seen in small-sized companies/contactors/subcontractors, medium-sized contactors/subcontractors, and some small/medium sized operation companies.

2.5.3 Stage-Gate process

The President of the Product Development Institute and the developer of Stage-Gate® model, Cooper (2008) conduces a study to re-evaluate the Stage-Gate Process and to clarify misconceptions and challenges in using the Stage-Gate Process. He found that the challenges of employing the Stage-Gate Process are governance issues, over bureaucratising the process, and misapplying cost cutting measures in product innovation.

He suggested some solutions; better governance method, clearly defined Gate-keepers/decision makers and their roles of engagement and leaner Gates to deal with bureaucracy. He found the Stage-Gate Process is not static but always changing and many companies adjust it to their own circumstances.

The creator of the Stage-Gate® Process, Cooper (2014) published an article in research-technology management that summarises a number of published articles and books under the title ‘What next after Stage-Gate?’ and the aim of this article to look at what leading firms are doing to move beyond their current Process (Idea-to-Lunch) and to integrate these practices into a next generation. He listed 25 points to compare traditional Stage-Gate with next generation system and found that no one company has implemented the whole 25 elements yet in order to move the next generation system of Stage-Gate.

Richard Wittig (2014) conducted a study to suggest a vertically integrated framework for the four study phases (Resource Planning, Concept, Pre-feasibility and Feasibility) through project development phase, and to outline the Australian mining industry practices for project development phase. He found that the current mega mining project practices require an integrated framework for Stage-Gate phases through project development to reduce cost and schedule overrun. He suggested a vertically integrated framework for the four Stage-Gate phases through project development in order to increase the links between project developments program and project portfolio management and presented a new vertically integrated model in an optimised project development life cycle.

Weijde (2008) conducted a research study in order to evaluate and to provide a scientific basis for understanding and analysing the FEL or Front-End Loading development phases/process of capital expenditure of oil and gas projects for Royal Dutch Shell, and to present a framework for fitting the front-end development to the specific project situation. FEL index is one of the six key performance indicators in IPA benchmarking that is used to measure the level of definition a project has attained at a moment in time (Weijde 2008). He found that project development phases or processes improved cost predictability, enhanced cost effectiveness, produced better schedule predictability and faster project delivery, optimised scope and operability and safety performance (p. 22).

Edkins et al (2013) conducted a multi-case exploratory investigation for the earliest stages of projects and project management by using in-depth interviews with 9 senior project management representatives of nine multinational project management companies in UK. The main aim of this investigation is to describe, understand and evaluate the front-end project management (FEL) since it is not well documented in the literature, and it is issues, responsibilities, roles and actions were too often ignored by 'official project management guidance' (p. 72). They found that 'aspects of the front-end management are not within the normal remit of what is considered to be traditional project management' (p. 71). Also they found a series of findings some related to process and other related to organization actors/decision makers. Moreover they found the project management PMBOK begins after the identification and collection of the project requirements but it has an important role prior to that point. They listed 7 points about the process and management:

A- Project Process:

1- Literature was not well documented the definition of FEL project management;

2- The way of thinking of project management during early phases (advice and recommendation of technology, schedule, risks, estimation, procurement, people) different than the way of thinking at the execution phase (complete on time and on budget);

3- In large, complex and urgent projects, economic and commercial considerations dominate project governance at the early stages and both fields have a lack of project management. There is a need for robust discipline for managing mega-projects;

4- A few companies worked in detail on an execution strategy but few had an explicit strategy. Most of the projects (e.g. oil companies), but not all (e.g. manufacturing companies), performed some systematic value management. Moreover formal algorithmic or proportional risk contingency plans were not allocated to budget; formal risk management was used in most cases.

B- Organization actors/decision makers:

5- In the Front-End loading early phases, the manager should fit the competency and should fit the project role;

6- There is a less freedom for individuals to do their own work in project management of larger organizations because of strict systems and standards, while in small creative and innovative project management companies' agility and informality are the norms;

7- 'The application of project management processes, the articulation of preferred methodology, and the definition of desired competencies was contingent on: (a) the characteristics of the project; (b) the characteristics of the environment the project is to operate in and (c) to some extent, the characteristics of the parent organization and the sponsor'(p. 83-84).

There is industrial information about project lifecycle starting from the early phase. Morris (1990) conducted a comprehensive survey in issues involves in initiation phase of project management or management of project from 1950 to 1980 and found that project management was reflected only in the project life cycle, and ignored in the critical front-end. Years later, a leading thinker in project management, Morris (2011) followed previous literature review and found that ‘It is evident from an extensive amount of research that management of the front-end definitional phases of projects is of overwhelming importance to their ultimate outcome yet we have little empirical data to suggest how best management competencies here should be improved’ (p. 7). He added that ‘If we want to be really effective in improving project management performance we should therefore be focussing on the front-end’ (p. 4). Morris (2013) in his study about reconstructing project management reprised from a knowledge perspective concluded that the ‘obvious immediate needs are to focus more on improving sponsor value and on shaping the context (process) in which projects and programs are formed and implemented’ (p. 23).

Shlopak et al. (2014) conducted a study of megaprojects and building projects’ Front-End Loading or FEL process (also referred to as Pre-Project Planning, Early Project Planning, Feasibility Analysis) to address construction issues related to planning within the pre-contract phase of shipbuilding megaprojects in Norway. They found that Front-End Loading or FEL process was not effective enough and for best practice process more efforts and work be needed. (p. 281)

Samset and Volden (2015) conducted seven in-depth case studies to explore strengths and weaknesses in the FEL processes of analysis and decision-making during the early phase before the final choices of conceptual solution were made in seven major public investment projects in Norway. They found that ‘governance or steer regimes for major investment projects comprise the processes and systems that need to be in place on behalf of the financing party to ensure successful investments’ (p. 2). They concluded that there are frequent deficiencies in these processes, and that the potential for improvements is huge, also ‘what happens during the front end phase is essential’ (p. 2). They added that the greatest potential for improvement lies in strengthening the analytical process, as well as making decision processes transparent. They summarised his findings in the following points (p. 3-8):

- Success is measured in terms of tactical performance rather than strategic performance;
- Less resources are used up front to identify the best conceptual solution (project governance), than to improve tactical performance during implementation (project management);
- Decisions are based on masses of detailed information up front rather than carefully selected facts and judgmental information relevant to highlight the essential issues;
- The choice of conceptual solution is made without systematically scrutinizing the opportunity space up front;
- Strategy and alignment of objectives are highlighted as essential concerns, but in most cases the internal logic of causalities and the probabilities of realization are erroneous.

Duimering et al. (2006) conducted a study, using interviews, with new product development process managers in a large telecom firm in Canada in order to examine the influence of product requirement ambiguity on new product development task structures. They found that new product development task structures change during the product development process as a result of requirement ambiguity, task expansion, contraction, substitution and combination. They also found that communication, coordination, knowledge and problem solving activities during project early phases effect on the project team of new project development tasks and activities structure. Moreover, they found that knowledge of how new product development project task structures evolve can lead to improved strategies for managing projects with ambiguous requirements. .

In conclusion, this part of the literature review shows that, currently, most international leading firms are using traditional Stage-Gate Process or Front end loading process, and trying to move toward a new fast-track generation of Stage-Gate Process, yet there is lack of understanding of the Stage-Gate Process and how it is implemented. These studies show this system can contribute to the success of a project. These studies, while not necessarily directed at megaprojects in the mining industry, nevertheless may be pertinent as they underscore the importance of achieving objectives.

2.5.4 Scope, scope changing and scope creep for engineering projects

It has long been suggested by some researchers that the more we try to close the process and reduce the scope of the project, the less influences we get from outside and the less feedback about alternatives and uncertainties is brought into the process (Deutsch 1966; Innes and Booher 2010).

A number of researchers have focused specifically on scope and scope change of mega-projects. (Shane et al. (2009) conducted studies on large scale public-private transportation projects for over 20 state highway agencies in order to determine the level of importance of estimates in establishing accurate performance expectations at each step of the project's development phase, and they found that around 50% of the active large transportation projects in the U.S. had cost overrun in their initial budgets. They also found that there were 18 internal and external factors that affect large scale projects cost estimation at the project development phase. (See Table 2.2). Moreover scope change and scope creep represent the main internal and external factors that affect cost estimation the preplanning phase. He concluded that ‘any one of the 18 cost escalation factors can taint the project for the owner, the designer, and contractor’ (p. 227).

Table 2.2: Internal and external factors affect the estimate in preplanning phase adapted from (Shane et al. 2009)

Internal factors	External factors
▪ Bias ▪ Delivery/procurement approach ▪ Project schedule changes ▪ Engineering and construction complexities ▪ Scope changes ▪ Scope creep ▪ Poor estimating ▪ Inconsistent application of contingencies ▪ Faulty execution ▪ Ambiguous contract provisions ▪ Contract document conflicts	▪ Local concerns and requirements ▪ Effects of inflation ▪ Scope changes ▪ Scope creep ▪ Market conditions ▪ Unforeseen events ▪ Unforeseen conditions

Source: Adapted from Shane et al. (2009)

Galloway (2009) stated that changing the scope of work during the design phase led to different effects from changes in the construction stage.

In Stage-Gate Process or Front-End Loading, phase FEL2 is specifically used to develop the scope and reliability of cost estimation for FEL3 and the whole project hangs heavily on completeness of scope developed in FEL2. Merrow (2011) pointed out that one of the scope development drawbacks is to precisely schedule it because of the shaping process during ongoing scope development phase.

Jergeas (2008) conducted research, survey 87 professionals and investigation for three Alberta mega-projects for oil sand in Canada with a total value of $10 billion Canadian dollars, and the research focus was on front-end loading with special emphasis on the project early engineering effort, and change to scope during the early stages of the project life cycle after the appropriation for expenditure. He found that ‘incomplete scope definition or inadequate Front-End Loading and poorly completed Front-end deliverables including milestone schedule slippage in Front-end loading' (p. 98). He added that some project strategies did not considered the level of scope definition.

In conclusion, these research studies show that scope change is still a major issue in engineering project management, especially when there is no scope change control in the project. Any poor preparation for project scope during the mega-project preplanning phase may lead to scope creep that could cause cost overrun.

2.5.5 Scope development and contracts

Many researchers, in addition to determining the factors affecting megaproject lifecycle related to cost, time and quality, and examining scope change, have examined the effects of contracts on scope. Smith (1995) conducted series of survey in UK for estimating, tendering and bidding for construction projects at preplanning phase three main factors may lead to inaccurate project estimates in UK: inappropriate assessment of risk, inappropriate contract strategies and human characteristics of the individual estimator.

Assaf and Al-Hajji (2006) carried out a study to determine the causes of large construction project delays during construction phase using a questionnaire survey on time performance with 15 owners, 23 contractors and 19 consultants. Their study found 73 causes of project delay in Saudi Arabia and found that the most common cause of delay identified was change order. They listed the causes of project delay during the construction phase that were related to contract (see Table 2.3).

Table 2.3: Contract issues related to causes of construction phase delay

No.	Causes of delay	Group
1.	Original contract duration is too short	Project management
2.	Legal disputes b/w various parties	Project management
3.	Inadequate definition of substantial completion	Project management
4.	Ineffective delay penalties	Project management
5.	Type of construction contract (Turnkey, construction only,)	Project management
6.	Type of project bidding and award (negotiation, lowest bidder,)	Project management

Source: Adapted from (Assaf and Al-Hajji 2006)

In 2006 the Australian contractor association and Black Dawson commercial law firm published a report with the findings of a study into Australian construction and infrastructure public and private projects. The report's key finding was 'the industry practice in relation to the scoping of big scale projects was often seriously inadequate' (p. 4). This may be the result of the inability of less able owners/clients to communicate their brief, needs and problems, and their lack of knowledge and ability to communicate the local standards/requirements/user-needs/fit-for-purpose-minimums and a lack of a knowledge-able main-contractor and sub-contractors. Lack of ability to provide a detailed brief may result in cost and time increases.

Regarding the contract strategy, Jergeas (2008) -mentioned previously- found that contract strategies relating to management, design, construction, and commissioning services were driven by time rather than cost. He added that there were a lack of knowledgeable leadership in procurement.

Loots et al. (2007) conducted a project study entitled: 'EPC and EPCM Contracts: risk issues and allocation' aimed to examined the advantages and disadvantages of each contract and its process (engineering, procurement, construction and management). They found that both contracts differed markedly and, in order to seek competitive tendering, the level of bid and tender package conditions presented by the project owner must neither be too general nor too detailed.

Another interview questionnaire survey study conducted by Al-Harbi et al. (1994) in Saudi Arabia in order to identify the need for a standard work item breakdown coding system, to provide consistent project and to identify the main problems facing estimators. He found that after compiling tenders for building works; there were tough competition, short contract period, incomplete drawings and specification, incomplete project scope definition, unforeseeable changes in material prices, change in owner requirements, current workload, error in judgement, inadequate production time data, lack of historical data for similar jobs, lack of experience for similar projects.

Akintoye and Fitzgerald (2000) conducted a questionnaire survey of 200 contractors in the UK (small, medium and large) to investigate cost estimating practices of contractors for construction projects. They found that the major causes of inaccuracy in cost estimating was insufficient time for tender preparation; poor tender documentation; insufficient analysis of the documentation by the estimating team; low level of involvement from the site team that would be responsible for construction; poor communication between the estimating and construction teams and lack of review of cost estimates by company management.

Shane et al. (2009) conducted an in-depth literature review on large scale public-private transportation projects for over 20 state highway agencies in US in order to determine the level of importance of estimates in establishing accurate performance expectations at each step of the project's development phase, and they found that 14 risk factors can escalate cost and increase possibility of cost overrun. They classified these factors into internal and external; internal factors can include ambiguous contract provisions, contract document conflicts inconsistent application of contingency and faulty execution. They added that ‘often only large contractors or groups of contractors can work or even obtain bonding for a large project. Size of the project affects competition for a project and the number of bids that an agency/owner receives for the work. Typically, the risks associated with large projects are much greater, both for the owner and contractor, and that affects project costs’ (p. 226). Moreover, they also found that large scale project ‘ambiguous contract provisions dilute responsibility and cause misunderstanding between an owner and project design and construction contractors’ (p. 225). They also found that contract document conflicts lead to errors and confusion while bidding and, later during project execution, they cause change orders and rework (Callahan 1998; Chang 2002; Harbuck 2004; Mackie and Preston 1998; Touran et al. 1994).

Singh et al. (2010) conducted a research study to investigate various issues related to delays and cost overruns in publically funded infrastructure projects. The data included 850 projects across 17 infrastructure sectors in India. They found and proved that there is a relationship between delays and cost overruns; the contractual and the institutional failures are economically and statistically significant causes behind cost and time overruns; also they found that delay and cost overrun occurred due to poor contractor selection and unethical behaviour, contract bid amount, difference between the winning bid and second bid, difference between the winning bid and the engineer’s estimate. He also found that a faulty contract management system and inadequate procurement system were the major reasons for project delay and cost overrun.

In conclusion, this section of the literature review reveals that relationship megaproject delay and cost overrun and their relationship with the scope of work, scope change and the contract strategy, bidding process and procurement system. These studies shows that importance of contract strategy for scope of work and success of the project starting from the preplanning phase of the project lifecycle. Contract, cost estimation based on the scope of work and work breakdown structure must be considered carefully at the preplanning phase.

2.6 Chapter Conclusion

In conclusion, this review of the literature has shown the importance of mega-project development processes, scope of work vagaries, and contract issues at the preplanning phase alongside their respective knock-on effects to project lifecycle related objectives; cost, time, quality and safety. There is somewhat of a lack of literature for big-projects' preplanning phase research in general and for mega-project preplanning stages specifically, and indeed it can be suggested that there has yet to be a definite agreement upon the extent to which mega-projects can be defined with specific definitions that go beyond a somewhat simplistic ~$1 billion catch-all categorisation. Research, it might be suggested, still needs to go towards work that explicitly explores traditional Stage-Gate processes for mega-projects in order to better address scope/scope-changes towards an overall approach to reducing project cost.

The work above presents an overview of contracts and contractors and stakeholder concerns and what elements might be factored into (mega) project initiation and development processes, respective scope(s)/scope(s)-changes and the related increases in project cost and time impacts. Building upon this body of previous work, this research develops the current understanding of change-order and scope-change associated with mega-project processes impacts, towards addressing relationship issues in totality.

The following chapter present this work's methodology to develop new data related to bettering mega-project engineering-management processes through analysis of a pre-planning phase evaluation for construction/mining endeavours.

CHAPTER THREE

3 METHODOLOGY

3.1 Introduction

Research methodology is defined by Strauss and Corbin (1998) as 'a set of procedures and techniques for gathering and analysing data' (p.3). This chapter discusses both qualitative and quantitative research methodologies, their advantages and disadvantages, the data collection method of the adopted methodology in order to meet the research objectives of this study (namely, to better mega-project engineering-management processes through analysis of a pre-planning phase evaluation for construction/mining endeavours), discussing also document analysis as an essential part of this methodology, and finally concluding with discussion of research validity and ethical issues.

3.2 Purpose of Study

Research and development strategies and integrated approaches guide research methods (Oyeneyin et al, 1996; Matori et al, 2014). This particular research was designed to evaluate the project management processes used in two mega-projects in Saudi Arabia in order to devise an improved project management process framework for the mega-project preplanning, initiation, prefeasibility, feasibility, and construction, delivery and also start-up phases.

The specific objectives of this research were to:

- Determine the process used in the early stages of the two megaprojects;

- Identify the measures used for the (mega)-projects at the early stages to avoid project life cycle problems and to speed up implementation of project activities without compromising the quality of work and project;
- Determine the factors impeding the effectiveness of the measures;
- Determine the personnel's knowledge in relation to technical tasks;
- Ascertain the adequacy of training in the process used;
- Determine the type and effectiveness of the megaprojects' contracts;
- Determine the internal and external factors affecting the effectiveness of the megaprojects' contracts;
- Establish the evaluation techniques used on the megaprojects and their effectiveness ;
- Determine the internal and external factors affecting the effectiveness of the evaluation techniques;
- Determine how scope of work, scope change and scope creep were mitigated
- Establish how risk was assessed and monitored during the pre-planning and construction phases;
- Establish to what extent technology and software were used and how effective they were in all the lifecycle stages;
- Evaluate the performance of the design teams from pre-planning through to feasibility stages;
- Determine the factors affecting the performance of the design teams from pre-planning through to feasibility stages;
- Determine the function analysis techniques used and their effectiveness;
- Establish which factors impeded the effectiveness of the function analysis.

3.3 Research Methodology

There are three types of research approach: qualitative, quantitative and a mixture of the two methodologies Creswell (2013). No single research methodology is necessarily ideal and that selection inevitably involves loss as well as gain (Schulze, 2003). Peter love et al. (2002) stated that 'there is no 'perfect' research methodology, as there is no universally agreed methodology.' This is because there is still great debate about the meaning of science (Lee, 1989). The following sections discuss two types of methodologies: quantitative and qualitative, and the advantages and disadvantages of each methodology.

3.4 Quantitative Methodology

Bryman and Bell (2011) describe quantitative methodology as 'entailing the collection of numerical data and as exhibiting a view of the relationship between theory and research as deductive, a predilection for a natural science approach, and as having an objectivist conception of social reality' (p. 150). Harwell (2011) stated that quantitative methodology inferences from tests of statistical hypotheses lead to general 'inferences about characteristics of a population' (p. 150). He added that it is 'typically interested in prediction' (p. 149).

It is best suited for testing a large population. (Walker 1985; Gill and Johnson 2010). It uses statistical analysis and focuses on measurement of events (Thomas 2003). Table 3.1 shows the questions the researcher needs to ask in order to determine if quantitative methodology is the type of methodology to use in his/her research (Leedy and Ormrod 2005, 96):

Table 3.1: Quantitative methodology distinguishing characteristics

Question	Quantitative
What is the purpose of the research?	- To explain and predict. - To confirm and validate. - To test theory.
What is the nature of the research process?	- Focused. - Known variables. - Established guidelines. - Predetermined methods. - Somewhat context-free - Detached view
What is the data like, and how is it collected?	- Numeric data - Representative, large sample - Standardised instruments
How is data analysed to determine its meaning?	- Statistical analysis - Stress on objectivity - Deductive reasoning
How are the findings communicated?	- Numbers - Statistics, aggregated data - Formal voice, scientific style

Source: Adapted from (Leedy and Ormrod 2005, 96)

3.5 Advantages and disadvantages of quantitative methodology

Quantitative research focuses on a specific question (Neuman 2010). Data gathering of quantitative research is highly reliable due to controlled observations, laboratory experiments, mass surveys, or other form of research manipulations (Balsley 1970). It is minimizing subjectivity of judgment, and allows for repeated measures of subsequent performance (Kealey and Protheroe 1996). Quantitative data analysis uses a statistical approach to test a hypothesis (Miles and Huberman 1994; Taylor and Bogdan 1984). However, characteristics of people and communities cannot be meaningfully reduced to numbers or adequately understood without reference to the local context in which people live (Dudwick et al. 2006, 3). Myers (2008) stated that ‘a major disadvantage of quantitative research is that, as a general rule, many of the social and cultural aspects of an organization are lost or are treated in a superficial manner’ (p 8). Lack of skills and resources, too, sometimes make large-scale quantitative research impossible (Dudwick et al. 2006, 3). Cassell , Dickson and Symon (2001) stated that 'the chief concern about the method would be reliability and validity' (p. 27). It (quantitative methodology) assumes a single truth and is independent of human perception (Lincoln and Guba 1985).

3.6 Qualitative Methodology

Qualitative research aims to produce factual descriptions based on face-to-face knowledge of individuals...in their natural settings (p. 196). Creswell (2003) describes qualitative methodology as 'one in which the inquirer often makes knowledge claims based primarily on constructive perspectives...or advocacy/participatory perspectives...or both (p.18). He (2008) added that it 'begins with assumptions, a worldview, the possible use of a theoretical lens, and the study of research problems inquiring into the meaning individuals or groups ascribe to a social or human problem' (p.37). Denzin and Lincoln (2000) comprehensively defined qualitative research as being 'a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self…qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them' (p. 3). (Ritchie and Lewis (2003) stated that qualitative research focuses on understanding rich description and emergent concepts and theories. Walker (1985) stated that a qualitative research method is concerned with processes of change, complicated topics and is suitable for small populations. Harwell (2011) stated qualitative methodology focuses on discovering and understanding the experiences, perspectives, and thoughts of participants' (p. 148).

Qualitative methodology suits strategies of inquiry such as case studies, narratives, grounded theory study, phenomenology and ethnography (Creswell 2003). He added that 'the researcher collects open-ended, emerging data with the primary intent of developing themes from the data' (p.18). Polonsky and Waller (2005) stated that qualitative data can be collected from the spoken word, printed word visions, images, forms and structures in various media, and recorded sound. Patton (1990) stated that written documents could include organisational excerpts, official reports, memoranda, publications, correspondence and program records. He divided qualitative research data collection into: in-depth open ended interviews, direct observation and written documents. Creswell (2003) divided the data collection procedures into: observations, interviews, documents, and audio-visual materials. Table 3.2 shows the questions the researcher requires to ask in order to determine whether or not qualitative methodology is appropriate to use in his/her research (Leedy and Ormrod 2005, 96):

Table 3.2: Qualitative methodology distinguishing characteristics

Question	Qualitative
What is the purpose of the research?	- To describe and explain - To explore and interpret - To build theory
What is the nature of the research process?	- Holistic - Unknown variables - Flexible guidelines - Emergent methods - Context-bound - Personal view
What is the data like, and how is it collected?	- Textual and/or image-based data - Informative, small sample - Loosely structured or no standardised observations and interviews
How is data analysed to determine its meaning?	- Search for themes and categories - Acknowledgement that analysis is subjective and potentially biased - Inductive reasoning
How are the findings communicated?	- Words - Narratives, individual quotes - Personal voice, literary style

Source: Adapted from (Leedy and Ormrod 2005, 96)

3.7 Advantages and disadvantages of qualitative methodology

Lincoln and Guba (1985) pointed out that both methodologies emphasize truth, consistency, applicability and neutrality with different procedural approaches to assure quality. Those who judge qualitative research by standards of quantitative research are often disappointed, and vice-versa (Neuman 2006, 151).

3.8 The advantages of qualitative research

The advantages of qualitative research can be summarized as follows:

- The basic interpretation of qualitative study is seeking to discover and understand phenomena, process, and the perspectives and worldviews of the people involved (Merriam 2001);
- ‘The primary strength of qualitative methodology is the ability to probe for underlying values, beliefs and assumptions. To gain a full appreciation of an organization, it is

necessary to understand what is driving their behaviour' (Yauch and Steudel 2003, 472);

- Peter Love et al. (2002) describes qualitative investigation as 'an interested in distilling meaning and understanding phenomenon. Interview, field notes, written documents and archives are the data collecting methods of qualitative research.
- Qualitative research 'is hypothesis-generating' (Merriam, 1989, p.20) rather than serving to test a hypothesis;
- 'Qualitative researchers do not narrowly focus on a specific question, but ponder the theoretical-philosophical paradigm' (Neuman 2006, p. 15);
- The goal of qualitative research focuses on "understanding, discovery, meaning, and hypothesis generation (Merriam 1998, p. 9);
- Qualitative methodologies associated with face to face contact with people, verbal date and observations. (Peter Love et al. 2002);
- It allows the research to study specific issues in detail (Burns 2000, 13; Patton 1990, 14);
- 'Qualitative approach 'inquiry is broad and open-ended, allowing the participants to raise issues that matter most to them' (Yauch and Steudel, 2003, 472);
- The strength of the qualitative research 'case study' approach is in its ability to examine a 'full variety of evidence – documents, artifacts, interview, and observations' (Yin, 2003, 8).
- Qualitative research provides a systematic, empirical strategy for answering questions about people in their own bounded social context (Peter Love et al. 2002).

- ‘The qualitative researcher does not have a preconceived, finite set of issues to examine’ (Yauch and Steudel 2003: 472);
- It suits theory-building and testing a theory (Myers 2008, 23);
- It focuses on rich description, understanding and emerging concepts (Ritchie and Lewis 2003);
- It is suitable for small populations, complicated topics and change processes (Walker, 1985);
- It provides rich data about situations, people, real life and behaviours (De Vaus 2002, 5);
- The findings are ‘generalizable to a large population and to theory but not by sampling logic’ (Myers 2008, 9);
- It has a great advantage over quantitative in that it has the ability to add more details after ending data collection time Fellows and Liu (2003);
- Data of qualitative methodology contain direct opinions, experiences and knowledge of participants (Patton 1990);
- Data analysis creates new concepts and the construction of theoretical interpretations (Neuman 2006, 15);
- Qualitative data analysis described by Wolcott (1994, p. 6) as the “systematic procedures to identify essential features and relationships.
- Qualitative research data analysis is a process of transforming the collected data through interpretation in order to discover a pattern of meaning, as well as a process of ‘bringing order, structure, and meaning to a mass of collected data’ (Marshall and Rossman, 1995, p. 111).

- The data may reveal subtleties missed by other data collection methods (Burns 2000, 13; Patton 1990, 14);
- Its data analysis endeavours to find, understand, describe or create a theoretical framework (Miles and Huberman 1994; Taylor and Bogdon 1984).

3.9 The disadvantages of qualitative research

The following is a summary of the disadvantages of qualitative research:

- 'It is often criticised for lacking generalisability, being too reliant on the subjective interpretations of researchers and being incapable of replication by subsequent researchers' (De Vaus 2002, 5);
- 'The major drawbacks associated with qualitative research cultural analysis are (a) the process is time consuming, and (b) a particular, important issue could be overlooked' (Yauch and Steudel 2003, 472);
- 'All researchers' interpretations are limited. As positioned subjects, personal experience and knowledge influence the observation and conclusion. The participants have more control over the content of the data collected' (Yauch and Steudel 2003, 473);
- 'There are multiple realities based on our construction of that reality (Lincoln and Guba 1985);
- The objectivity of qualitative data is questioned by the researcher of quantitative approach (Fellows and Liu 2003);
- 'Analysis of the qualitative data tends to be considerably more difficult than the quantitative data, often requiring a lot of filtering, sorting, and other manipulations to make them suitable for analytic techniques' (Fellows and Liu 2003, 29);

- Qualitative research may be impacted by limited time of data collection analysis and interpretation (Thomas 2003);
- Data collecting tool is the researcher who may invoke questions of reliability and validity (Burns 2000, 13; Patton 1990, 14);

To ensure reliability, three strategies were employed in this research: (1) the researcher provided a detailed explanation of the focus of the study, the researcher role, the participant's position and basis for selection (Creswell 2009); (2) multiple methods of data collection and analysis were to strengthen reliability as well as internal validity (Merriam, 1989); and (3) data collection and analysis process were reported in detail in order to provide a clear and accurate picture of the methods used in this study (Merriam, 1989). This research study was not designed to test hypotheses or analyse statistical data. The main aim of this research was to study and evaluate project preplanning phase issues and to evaluate ongoing concerns of scope change and issues of change orders from the early stage of megaproject lifecycle. The sole sources of this kind of information were the expertise of personnel who were part of the technical and non-technical higher management and execution teams at the preplanning phase during the implementation of this phase, and also project documents.

The methodological approach chosen for this research was, therefore, qualitative in order to obtain expert points of view about the events which had affected the course of the two megaprojects starting from the preplanning phase, including the project lifecycle, particularly to examine and evaluate the reasons behind the continuous change orders and scope of work change of both megaprojects.

Data of two case studies were collected from different chief executive officers, vice presidents, executives and higher management of the two subsidiaries and a partner of one of the megaprojects. This was achieved by doing semi-structured interviews and two case studies for two mega-projects processes, with two subsidiaries that worked under the supervision of the parent company.

3.10 Data Collection

Patton (1990) stated there are three different methods of qualitative research data collection, namely, interviews, direct observation and written documents. Data for this research were collected from 15 high profile experts in two public subsidiaries and from one private partner for one of the two megaprojects. Polkinghorne (1989) recommends that researchers interview from 5 to 25 expert individuals who know the phenomena. The following sections discuss the in-depth case study, in-depth interviews and documents of the data collection.

3.11 In-depth case study

Saunders et al. (2003) divided the research into six stages to include: technique and procedure, time horizons, choices, strategies, approaches and philosophy. He also divided the strategies into six categories to include: case study, experiment, survey, action research, grounded theory, ethnography and archival research.

Case study research is a strategy of inquiry, a methodology and a comprehensive research strategy (Denzin and Lincoln, 2005; Merriam 1998; Yin 2003). Creswell (2007) defined case study as ‘a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g. observations, interviews, audio-visual materials, and documents and reports), and reports a case description and case-based themes' (p. 73). It 'is a heterogeneous activity covering a range of research methods and techniques, a range of coverage from single-case study through carefully matched pairs to up to a dozen cases, differing lengths and levels of involvement in organizational functioning and a range of different types of data analysis' Hartley 1994, 208; Hartley 2004, 323).

Yin (2003) stated that case study is used to evaluate the 'why' and 'how' questions of exploratory research (p. 5). According to Yin (2003) 'the distinctive need for case studies arises out of the desire to understand complex social phenomena' because 'the case study method allows investigators to retain the holistic and meaningful characteristics of real-life events' (p. 2). Hartley (2004) stated that a case study is useful to understand how organisational and environmental context impacts on processes. Case study data helps to identify entity problems and improve solutions (Kothari 2004; Balsley 1970). Thomas (2003) stated that in case study, the researcher can reveal the interaction of processes that create entity actions and character.

According to Creswell (2007), there are three types of case studies:

1- Single case study.

2- Collective case study.

3- Intrinsic case study.

In single case study, the researcher focuses on one issue, and then selects one case to illustrate the issue, while in collective case study, an issue is again selected, but the inquirer selects multiple case studies to illustrate the issue (Stake 1995). Yin (2003) suggested that the collective case studies design uses the logic of replication in which the inquirer replicates the procedures for each case. The third type of case study is an intrinsic case study in which the focus is on an unusual or unique situation such as evaluating a program and narrative research (Stake 1995). Case studies can have six sources of evidence: documents, archival records, interviews, direct observation, participant observation, and physical artifacts (Yin 2003, 83-85-96). Yin (2003) stated that rigorous data collection follows carefully articulated steps: the use of multiple sources of evidence, the creation of a case study database, and the maintenance of a chain of evidence. The reliability of the case study is more important than generalization to other similar cases (Bell 1999).

3.12 Advantages of case study

- It provides in-depth understanding of several cases (Creswell 2007, 74);
- It allows to discover and test theories for real life practices (Myers 2008, 82);
- It can deal with a variety of evidences, documents, interviews, and observations (Yin 2003, 8);
- It used when there is a gap and ambiguity of evident between a context and phenomenon (Yin 2003, 13);
- It is useful when there is an interest in discovering the 'multiple realities' of participants (Stake 1995, 64);
- Useful to understand how organisational and environmental context impacts on processes (Hartley 2004);
- It helps to identify entity problems and improve solutions (Kothari 2004; Balsley 1970);
- In case study, the researcher can reveal the interaction of processes that create entity actions and character (Thomas 2003).

Yin (2003) criticised those who said case study provides little basis for scientific generalization by saying ‘case studies…are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study… does not represent a 'sample', and in doing a case study, your goal will be to generalize theories (analytical generalization) and not to enumerate frequencies (statistical generalization) (p. 10). However, Yin (2003) conceded that there were two disadvantages to case study; it consumes time and the results can be unreadable. Creswell (1998) suggested steps to analyse the case study data:

1- Arrange specific facts in a logical order;

2- Categorise data;

3- Examine the relationship of data occurrences;

4- Identify patterns of data interpretation and pattern that criticise the case more broadly than a single piece of information;

5- Synthesise and generalise conclusions.

Yin (2003) stated that 'no matter what specific analytic strategy or techniques have been chosen, the researcher must do everything to make sure that the analysis is of the highest quality', adding that the researcher ‘must be able to develop strong, plausible, and fair arguments that are supported by the data’ (p. 137)

This research examined lifecycles of two megaproject management processes starting with the preplanning phase for two public entities that work under the supervision of the parent company, an aluminium megaproject and a gold megaproject in Saudi Arabia. The aluminium megaproject is a joint venture fully integrated industrial complex producing aluminium for domestic and world markets from mine to rolled product. It includes a mine, alumina refinery, aluminium smelter and a rolling mill. The megaproject complex uses clean power generation, sea port and rail facility. The gold mega-project consists of five mines, five advanced exploration refineries and properties. The two mega-projects faced many difficulties during the two megaproject life cycles, leading to delayed project schedule and increased project budget. Case study data were collected from CEOs, VPs and executives of the two subsidiaries and one project main partner. Case studies of this kind can help the researcher to understand the approaches taken by top management when implementing mega-projects at the preplanning phase.

3.13 In-depth interview

Boyce and Neale (2006) defined in-depth interviews as 'a qualitative research technique which involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program or situation' (p. 3). Kvale (1983) stated that the purpose of the qualitative research interview is 'to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena' (p. 174). Patton (2002) classified the interview data collection method into three general categories: the informal, conversational interview; the general interview guide approach; and the standardized, open-ended interview. Interviews suitable for complex situations can be divided into three categories:

1- Structured interview (rigid questions, content and structure).

2- Semi-structured interview (elements of both structure and unstructured).

3- Unstructured interview -flexible questions, content and structure- (Patton 1990).

Berg (2009) stated that semi structured interview is designed to collect data by using a set of predicted and predetermined questions to provoke thoughts and opinions of related issues. Therefore, in this research the primary data of face to face semi-structured interview (open interview approach with note taking) was designed and incorporating 84 questions in order to determine the circumstance and the events that led to cost overrun and delay of mega-projects schedule at the project lifecycle including preplanning phase, design, construction, start-up. The CEO's of both subsidiaries allowed the interviewees to support the researcher and to answer the interview questions freely and without introducing bias in the response. The interview and data collection of both mega-project processes were supported by official and formal letters from the government, two CEOs' and university.

3.14 The advantages of interview

The advantages of interview can be summarised in the following points:

- The main advantage of interview is the possibility of obtaining comprehensively detailed primary data (Saunders et al. 2003);
- Interview data is rich in information and detail (Denscombe 2004);
- Interview is a flexible approach and used widely for in-depth data collection (Robson 2002; King 2004);
- It provides participants' direct opinions, experiences and knowledge (Patton 1990);
- Semi-structured interview can be structured for a cross-case comparison (Bell and Bryman 2007);
- There is the probability of instantly validating the data (Denscombe 2004).

However, disadvantages of the interview can be:

- Interview research issues must be handled carefully in order to manage interview time efficiently (Bell and Bryman 2007);

- Warren (2002) stated that the interviewer must remain focused on the research questions or objectives in order to ensure the interviewee remain focussed on the question;

The main disadvantage of the face to face interview is, it is expensive and time-consuming;

- There is the possibility of interviewee bias during the data collection (Engel and Schutt 2009);
- Interviewee bias could seriously compromise the validity of the project findings (Engel and Schutt 2009).
- Connaway and Powell (2010, 171) suggested that in order to avoid interviewer bias; the interviewer does not overreact to responses of the interviewee

Fellows and Liu (2003) Figure 3.1 shows that the differences between questionnaires, case study and interview in relation to the depth and breadth of the study and the data required. It demonstrates that the questionnaires cover a large sample without giving in-depth information; however case studies and interview are deep and focussed to gather the necessary information.

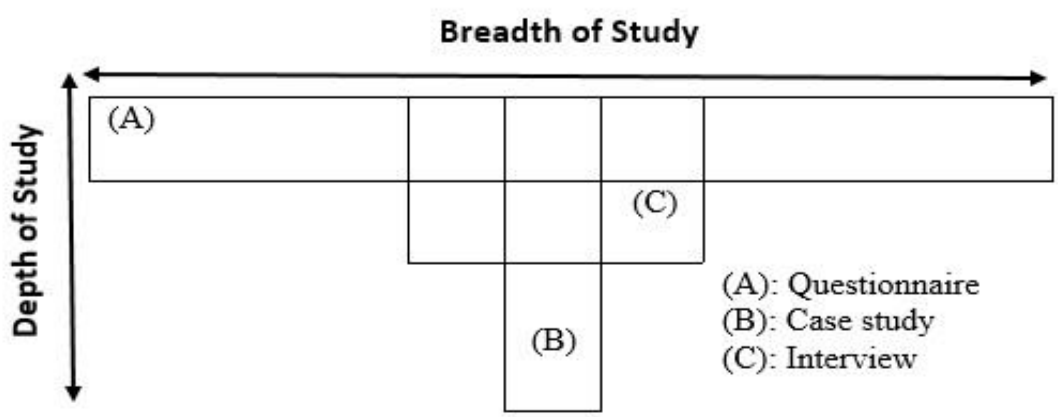


Figure 3.1: Breadth vs. depth in question-based studies. Source: Fellows and Liu (2003)

This research used semi-structured face to face interviews and all interviews were conducted in a friendly environment and at times and places that suited the interviewees. The data of this research was in-depth, rich, and from a relatively small population sample. It dealt with high profile management in order to determine the preplanning process for two megaprojects and the associated issues of the two lifecycles.

The interviews were held individually with fifteenth executives including three CEOs, three VPs, five Directors and four managers in four different cities, and for over three months.

The interviewer started the interviews by visiting the gold company and met the CEO and directors of gold companies and a VP in two different locations away from each other; the main business department and the project management department.

After spending a long time with the Western-region gold company the interviewer travelled to a different city in the centre of the country to meet headquarters higher management VPs, and director(s) of contracting and procurement. Due to the tight schedules of executives, the interviewer tried several times to assigned a meeting with them almost failing; however the researcher persisted and met the director of contracting and procurement. Moreover the interviewer travelled to two other cities in the East of the country in order to conduct the interviews with the members of Aluminium mega-project and one of the mega-project partners. Commencement of the interviews was through visiting the project partner and meeting the CEO and planning managers who worked for the project from the preplanning phase and upon gaining a site permit (a not uncomplicated process in itself) visits and data gathering was carried out at this mega-project location, conducting interviews with the CEO, directors and managers respectively.

The researcher gave interviewees the time to answer the semi-structured questions without interruption and genuinely engaged with each interviewee and transcribed important information during conversations via direct written note taking (due to the confidential nature of some of the information, recording were agreed as not to be used).. Interviewees were helpful and provided wherever possible valuable sensitive information for the two mega-projects' case-studies, and tried to explain and clarify fine points for each and every question. Moreover the researcher managed to build up a good relationship with interviewees over the three months period of interaction allowing a number of re-confirmations and more importantly validation of both the responses and the recommendation proposal (as below) for a framework for mega-project improvement with direct reference to pre-planning factorisation/weighting.

3.15 Interviewee

This research project recognizes: the senior experts representing case-study 'gold'; the expert advisers representing case-study 'aluminum'; and, the expert senior executives representing case-study 'headquarters', all detailed below.

A- Gold subsidiary

Table 3.3 shows six senior directors and managers of the mega-project team of gold.

Table 3.3: Project team of gold subsidiary

Interviewee	Position	Experience	Client/ Partner	Industry	Sector
Interviewee 1	President of gold Co. & vice president of Co.	25 years	Client	Mining	Semi- Gov’t
Interviewee 2	Director of new mines	15 years	Client	Mining	Semi- Gov’t
Interviewee 3	Project director & execution	18 years	Client	Mining/Petro-chemical	Semi- Gov’t
Interviewee 4	Manager of Engineering projects & QA/QC	17 years	Client	Mining/Petro-chemical	Semi- Gov’t
Interviewee 5	Mining project manager	16 years	Client	Mining/Petro-chemical	Semi- Gov’t
Interviewee 6	Manager, project control & risk management	14 years	Client	Mining/Petro-chemical	Semi- Gov’t

B- Aluminium subsidiary

Table 3.4 shows six senior directors and managers of the mega-project team of Aluminium.

Table 3.4: Project team of Aluminium subsidiary

Interviewee	Position	Experience	Client/ Partner	Industry	Sector
Interviewee 7	President of Aluminum Co.	30 years	Client	Mining/Petro-chemical	Semi-Gov't
Interviewee 8	Deputy project director	20 years	Client	Mining/ Oil & Gas	Semi-Gov't
Interviewee 9	Deputy project director	20 years	Client	Mining/Chemicals	Semi-Gov't
Interviewee 10	Financial planning & analysis manager	14 years	Client	Mining/Petrochemical	Semi-Gov't
Interviewee 11	President of petrochemical Co.	27 years	Partner	Petro-chemical	Private
Interviewee 12	General manager of planning	34 years	Partner	Petrochemical	Private

C- Corporate Executives or Higher Management (Headquarters details)

Table 3.5 shows that three executives of the two mega-projects at the headquarters.

Table 3.5: Higher management interviewees at the headquarters

Interviewee	Position	Experience	Client/ Partner	Industry	Sector
Interviewee 13	Vice president of project Management & Engineering	34 years	Client	Mining/ Oil & Gas	Semi-Gov't
Interviewee 14	Vice president of corporate Control & enterprise Risk management	29 years	Client	Mining/ Oil & Gas	Semi- Gov't
Interviewee 15	Director contracts & procurement	26 years	Client	Mining	Semi- Gov't

3.16 Document Analysis

Yin (2003) recommends different types of information sources for data collection such as documents, archival records, interviews, direct observations and participant-observations. Creswell (2009, 185) listed the following analysis steps of qualitative data:

1- Prepare and organise the data for analysis;

2- Prepare the data and information to obtain overall meaning;

3- Read, organise and reflect on the meaning;

4- Code, categorise and label data based on the theoretical approach;

5- Use a narrative passage to generate a description of people and identify themes from coding and find the connections between the themes;

6- Interconnecting themes and tables;

7- Interpret the more meaning of data and represent the information and data in the report.

Data collection method of the two-megaproject lifecycles such as prefeasibility, feasibility, construction and start-up, were gathered from documents as well as interviews.

Document analysis for this research is undertaken to understand the whole picture of case studies and include individual official interviews and documents such as technical and non-technical reports, annual reports, design and drawings documents, specifications, financial information, work activities and tasks, contract agreements, minutes of meetings, internal memoranda, booklets, brochures and journal article and newspaper. Moreover document analysis of this research contained detailed plans of work, design documents, work activities and tasks, company information, contract agreements, booklets and brochures. These phases, disciplines, areas, tasks and activities during the two megaprojects life cycles were divided, categorised and studied carefully. These data and documents were compared with the interview data to assure validity and to uncover any differences. The following Table 3.6 describe the procedures supported by the authority.

Table 3.6: The procedures supported by the authorities

Procedure	Authority
The two-megaproject lifecycles data; prefeasibility, feasibility, construction and start-up data	Documents of both companies including all interviewees.
Technical and non-technical reports	Documents of projects including project management department for both subsidiaries including the main contractor.
Individual official correspondence	Higher management and project management team for both of subsidiaries.
Financial information	Documents of projects including Financial planning & analysis manager
Detailed plans of work	Documents of projects including Higher management and CEOs' of both subsidiaries including CEO and main partner General manager of planning
Design documents	Documents of projects including Project management departments of both subsidiaries including the project management department of main contractor.
Work activities and tasks	Documents of projects of all departments
Company information	All Companies
Contract agreements	Documents of projects including higher management including CEOs' of both companies including CEOs' and the planning manager of main contractor

Annual reports	All companies
Booklets and brochures	All Companies
Journal article and newspaper	Researcher

3.17 Validity

Validity is defined by Creswell and Clark (2007) as 'the ability of the researcher to draw meaningful and accurate conclusions from all of the data in the study' (p. 146). According to Leedy and Ormrod (2005), 'the validity and reliability of your measurement instruments influence the extent to which you can learn something about the phenomenon you are studying...and the extent to which you can draw meaningful conclusions from your data' (p.31). In qualitative research credibility, neutrality or confirmability, consistency or dependability and applicability or transferability are the essential criteria for quality of the study (Lincoln and Guba 1985).

Trustworthiness is the term used in parallel to validity in qualitative research (Guba 1985; Lincoln and Guba 1985). Trustworthiness of a research report urged by Lincoln and Guba (1985) as the heart of issues conventionally discussed as validity and reliability. Guba and Lincoln (1985) divided trustworthiness into four categories: credibility, transferability, dependability and confirmability. They proposed that internal validity should be replaced by that of credibility, external validity by transferability, reliability by dependability and objectivity by confirmability (Guba and Lincoln 1982). The following sections summarise the four main categories of trustworthiness.

The researcher's methods involve the 'use of standardised measures so that the varying perspectives and experiences of people can be fitted into a limited number of predetermined response categories to which numbers are assigned" (Patton 2001, 14). He added that the credibility in quantitative research depends on instrument construction, while in qualitative research, ‘the researcher is the instrument’ (Patton 2001, 14). It involves establishing the results as credible from the perspective of the participants in the research (Trochim 2001). Member checking is the most crucial technique for creating credibility (Lincoln and Guba 1985). In order to create credibility, different sources of information, including investment of sufficient time by the researcher, create credibility (Driessen, et al. 2005).

Newman and Ridenour (2008) referred transferability of qualitative research to the ability of the findings to be generalised to other contexts and not be limited. Seale (1999) claims that transferability of qualitative research replaces external validity. External validity, ‘is concerned with the extent to which the findings of one study can be applied to other situations’ (Merriam, 1998, 207). In order to increase the credibility of qualitative research for transferability, Lincoln and Guba (1985) suggested the use of thick description of data.

Dependability is the third way to judge the qualitative research validity or trustworthiness. Lincoln and Guba (1985) stated that dependability shows the consistency and repeatability of research. Consistency or stability used over the time of the research inquiry process are needed for dependability (Golafshani 2003). Lincoln and Guba (1985) stress the close ties between credibility and dependability in practice and argue that they may be achieved through the use of individual interview or group focus. Inquiry audits of the research documents and the report can help the independent auditors to judge the credibility, transferability and dependability of the research findings (Lincoln and Guba 1985).

Confirmability in qualitative research is defined by Given (2008) as ‘an accurate means through which to verify the two basic goals of qualitative research: (1) to understand a phenomenon from the perspective of the research participants and (2) to understand the meaning people give to their experiences and it can be expressed as the degree to which the results of the study are based on the research purpose and not altered due to research bias' (p. 112). Schwandt (1997) stated that confirmability 'calls for linking assertions, findings and interpretations and so on to the data themselves in readily discernible ways' (p. 164). The rigour of qualitative findings is the purpose of ensuring confirmability (Guba 1981; Schwandt, Lincoln, and Guba 2007). Guba and Lincoln and (1985) suggested an external audit for dependability and confirmability in order to increase the credibility of qualitative research. Given (2008) stated that 'an independent reviewer is allowed to verify the research process and interpretations of the data as consistent on both the literature and methodological levels (p. 112).

In order to ensure validity the researcher spent more than three months at the company offices and site to collect data, and was given leave to remain with the interviewees in order to build up a close relationship and to examine and clarify any misunderstanding in the data provided of work process during project lifecycle.

In order to achieve research trustworthiness and to ensure its acceptability, prior to conducting the data collection, the researcher was required to obtain 'official approvals' from the heads of the two subsidiaries and an official letter from the government in order to obtain permission to collect data from staff presumed to have the ability to contribute their perspectives based on sound knowledge.

The interviewees were selected carefully to target those who had worked during the preplanning phase of two mega-projects. Research data-gathering timetables sought and managed to secure interviewees at the appropriate initial stages of the two-mega-projects. Interview answers obtained from stakeholders who worked for the project from initiation, in the project management department, financial department, mines, quality control, execution department and respective ‘start-up’ sub-departments. All aspects of the project lifecycle were covered in the interviews with personnel. Data were analysed and the transcripts were read twice – the first time to search for the main themes and the second time to categorise and code the data. Transcripts were written up by using rich and thick description. The research used different sources of information – two different mega-projects and also sought data from higher management of the parent company and the CEO, as well as from the higher management of the project partner (petrochemical firm). Table 3.7 outlines the strategies undertaken to validate the research against the validation criteria.

Table 3.7: Summary of Strategies to Validate Research

Qualitative validity criteria	Strategy	Action
Credibility	Prolonged Engagement	The research mission lasted for more than three months.
	Triangulation	Different sources, different questions and different approaches; Two mega-projects, two subsiders and one partner, 3 CEOs’,2 VPs’, executives, directors managers, and 84 questions
Transferability	Use of Thick Description	Sufficient detail and full report of interpretation of findings are presented for the reader.
	Clarification of Bias	Unbiased data collection approaches adopted / supported for the main source of information (Government and CEOs’.
Dependability	Inquiry Audit	Independent examination/validation of the research process, documents and interview data, findings, interpretations, roadmap and recommendations.
Confirmability	Raw Data	Two case studies, two mega-projects, two subsidiaries, one partner and eighty four questions and answers for interviewees, all had checked by the inquiry auditors’.

3.18 Ethical Conduct in Research

All Research at Curtin University who are conducted research with or about people, or their data must conduct it in accordance with the Australian Code for the Responsible Conduct of Research. Clause 4.2.2 of states that ‘Institutions must maintain a policy that protects the intellectual property rights of the institution, the researcher, research trainees and sponsors of the research, as appropriate.’

3.19 Ethical issues

Occasionally the different methods of conducting qualitative research of subjective industrial projects have ethical issues due to many factors such as the interview itself, the nature of collecting data, and researcher interpretation (Pasian 2015). Pasian stated that a list of ethical considerations include obtaining the informal consent of participants, safeguarding employee matters, safeguarding against bias in interpreting the data, installing protective measurements to safeguard employees against being fired for participating in research, asking effective questions, not drawing conclusions from a general case, applying critical thinking in all research analysis and interpretation (Pasian 2015, 146).

Generally, the key ethical issues that arise during data collection or interviewing, are due to sensitivity of information, and in this qualitative research and prior to the interview, the researcher sent official requests to the CEOs of the two public mega-projects and a confidentiality agreement was put in place among the university, the researcher and the two companies. Moreover, the researcher also obtained an official permission from the government supporting the research for three months. The assistants of the two CEOs were instructed to provide all necessary information for the researcher. A copy of the research findings was promised to the government at the end of the research. Thus the researcher assured the interviewees that the companies' rights and matters would be safeguarded and confidentiality would be maintained. The interviewees were also assured that they and the company would remain anonymous. And to ensure anonymity, interviewees were given generic aliases. The interviewees were also informed that their participation in the study was voluntary and they could withdraw from the study at any time.

3.20 Chapter conclusion

This study utilised qualitative methods of data collection to evaluate the mega project management process being applied in two public mega-projects at the project development phase in Saudi Arabia. These two mega projects were researched as two case studies, in which the interviews with higher management engaged in megaprojects preplanning phase and review of documents were combined to generate a megaproject roadmap from the preplanning phase. The data from two mega-projects for the same company, in different locations, with different management, contractors and documents allowed comparison and contrast between the two case studies.

CHAPTER FOUR

4 INTERVIEW ANALYSIS

4.1 Interviewee Details

Interviewees from the gold subsidiary, the aluminum subsidiary and headquarters were asked to provide information on their position, experience, department and involvement in the mega-project. This information is summarized in Table 4.1, Table 4.2 and Table 4.3 respectively.

Part 1: Gold Subsidiary (Projects team details)

Six senior directors and managers of the project team were asked a series of questions about the Mega-project's development and execution phases.

Table 4.1: Project team of gold subsidiary

Interviewee	Position	Experience	Client/ Partner	Industry	Sector
Interviewee 1	President of gold Co. & vice president of Co.	25 years	Client	Mining	Semi- Gov't
Interviewee 2	Director of new mines	15 years	Client	Mining	Semi- Gov't
Interviewee 3	Project director & execution	18 years	Client	Mining/Petro-chemical	Semi- Gov't
Interviewee 4	Manager of Engineering projects & QA/QC	17 years	Client	Mining/Petro-chemical	Semi- Gov't
Interviewee 5	Mining project manager	16 years	Client	Mining/Petro-chemical	Semi- Gov't
Interviewee 6	Manager, project control & risk management	14 years	Client	Mining/Petro-chemical	Semi- Gov't

Part 2: Aluminum Subsidiary (Project team details)

Eight senior directors and managers of planning and executing project management team were asked a series of questions about the Mega-project development and execution phases.

Table 4.2: Project team of aluminum subsidiary

Interviewee	Position	Experience	Client/ Partner	Industry	Sector
Interviewee 7	President of Aluminum Co.	30 years	Client	Mining/Petro-chemical	Semi-Gov't
Interviewee 8	Deputy project director	20 years	Client	Mining/ Oil & Gas	Semi-Gov't
Interviewee 9	Deputy project director	20 years	Client	Mining/Chemicals	Semi-Gov't
Interviewee 10	Financial planning & analysis manager	14 years	Client	Mining/Petrochemical	Semi-Gov't
Interviewee 11	President of petrochemical Co.	27 years	Partner	Petro-chemical	Private
Interviewee 12	General manager of planning	34 years	Partner	Petrochemical	Private

Part 3: Corporate Executives or Higher Management (Headquarters details)

Three executives were asked random questions about the Mega-project's lifecycles.

Table 4.3: Higher management interviewees at the headquarters.

Interviewee	Position	Experience	Client/ Partner	Industry	Sector
Interviewee 13	Vice president of project Management & Engineering	34 years	Client	Mining/ Oil & Gas	Semi-Gov't
Interviewee 14	Vice president of corporate Control & enterprise Risk management	29 years	Client	Mining/ Oil & Gas	Semi- Gov't
Interviewee 15	Director contracts & procurement	26 years	Client	Mining	Semi- Gov't

4.2 Interviewee Question and Response

The following tables represent the questions that given to the interviewees of the gold subsidiary (interviewee 1 to interviewee 5), the aluminum subsidiary (interviewee 6-interviewee 12) and the headquarters (interviewee 13-interviewee15), and their responses.

4.2.1 Traditional project management and stage-gate processes

Table 4.4: Responses

Table 4.4: Responses to traditional project management and stage-gate processes

1. How did you evaluate the stage-gate process at the Mega-project concept and prefeasibility phase?	
Interviewee 1	-We have just started implementing stage-gate process in the company; however we used its process to evaluate the three stages of the design processes with the design contractor. -Stage-gate process used at project basic design stage in the prefeasibility phase. -Stage-gate management approval for project basic design (3D HAZOP) stages took from one month to two months each review stage represents: Design (30%) then Design (60%) then Design (90%). -Stage-gate process will be applied on all future projects but the theoretical process needs modification to suit the mining sector and specifically our company.
Interviewee 2	-Stage-gate process is not well identified. -Stage-gate process consumes a long time for analysis, evaluation and finally the final approval of board members which took long time to obtain their signatures.
Interviewee 3	-Stage-gate approval was the main cause for change orders. -Stage-gate team lacked of technical experience and needed to study all the - aspects of the stage before evaluating them in an independent peer review.
Interviewee 4	-Stage-gate review was important and should include the whole stakeholders such as the project team, contractor, owner and operations. -Stage-gate workshop and process covers economic parameters such as IRR, - ROI & PV value engineering and HAZOPS.
Interviewee 5	-Stage-gate was a good tool and all stakeholders must involve in the process and evaluation.
Interviewee 6	No answer was given
Interviewee 7	-Stage-gate should link to the right department. -We did not use stage-gate process at early phases since we had small project management team at the prefeasibility stage of the project and the main project management contractor took the responsibilities of project supervision.

Interviewee 8	We did not used it except in the design stage but the contractor did during the project life processes.
Interviewee 9	No answer was given
Interviewee 10	No answer was given
Interviewee 11	We did not used stage-gate project instead we used the traditional project management since we have small project management team.
Interviewee 12	We did not deal with stage-gate project at the project prefeasibility stage, the reason was that the stage-gate review consumes project time (signature of the board members). Instead we used regular meetings, PowerPoint slides, project cost estimation and project daily follow up.
Interviewee 13	We just introduced stage-gate process to the company and still working on traditional project management.
Interviewee 14	We used traditional project management and moving toward stage-gate process
Interviewee 15	No answer was given

4.2.2 Mega-project scope of work and scope creep

Table 2: Responses

Table 4.5: Responses to Mega-project scope of work and scope creep

2. How did you evaluate scope and scope creep?	
Interviewee 1	Inaccurate of ore data-base (quantity and quality) and basic design problem at the early stages caused a scope creep.
Interviewee 2	-Scope creep arises from basic engineering packages, we spend a lot of efforts during this stage. -Well project definition and scope of work will minimize the scope-change. -We changed scope order once or twice a month for 22 months project. -Scope of work was the main on-going costs of project.
Interviewee 3	-The major cause of scope creep was the owner. -Contract award selective based on low price and this hurts the scope and lead to change it. -Different thoughts and concepts for project team.
Interviewee 4	Scope definition is not clear.
Interviewee 5	Project owner must define project scope properly.
Interviewee 6	-Contractor or consultant that did the design offshore and did not know the actual local market properly caused a scope creep.
Interviewee 7	-Contractor and subcontractor. -Project team.
Interviewee 8	-Number of awarded change order, after award of contract is a good tool to show how good the scope was described and how much is the scope creep.

	-To reduce the scope creep, we need owner must defined the scope of work properly. -We changed the scope more than 5 times during construction phase and many times during basic/detailed engineering. -Project scope creep caused a major continuing cost.
Interviewee 9	-Lack of authority cooperation. -Project interfaces. -Licenses (labor, location, etc.). -Contractor and subcontractor.
Interviewee 10	-Site condition. -Utilities. -Services. -Contractor. -Lack of expertise. -Transformation from project to operation. -Inaccurate cost estimation from the contractor. -Owner change order at the construction phase (to increase the capacity).
Interviewee 11	-The technology provider is the best entity that can do the project basic engineering if you want to avoid and scope creep. -Inaccurate project information at the beginning of the project. -Unstable of water, electricity and gas supplies. -Inaccurate raw material information. -Inaccurate basic design. -Unproven technology. -Kind of contract. -Bank loan. -Project team. -Sometimes partnership. -Contractor and suppliers.
Interviewee 12	-Stage-gate process and board approval

	-Strategy and type of contract -Partnership with technology provider. -Complexity of project procedures -Project team -Neglecting in failing to follow-up a project on daily-basis
Interviewee 13	-Project loan. -Change management. -Contractor.
Interviewee 14	-Poor planning. -Vendors and suppliers.
Interviewee 15	-When scope is unknown like project engineering rate then we can use unit rate contract. -Contract strategy could lead to scope creep.

4.2.3 Contract strategy and award mechanism

Table (3): Responses

Table 4.6: Responses to contract strategy and award mechanism

3. Was the current contract award mechanism in your company Effective?	
Interviewee 1	-No it was not, the contract types used were EPCM: open for plant, EPC: close for roads and small jobs. -Company follows contract awards procedure to choose the winner but there were a problem with the clauses and contract type itself.
Interviewee 2	-We had a problem with the main contractor award. -EPC type of the contract was the most used not EPCM. -Main contract award has a problem. -The traditional procurement contract (Design-Bid-Build) was not effective and needs for improvement.
Interviewee 3	-Contract award selection system based on the low price and this hurts the scope and led to changed it. -EPCM type of contract is not successful in this country. -We put unrealistic time condition in the contract clauses. -Contract structure/strategy is a big problem. -Contract type wasn’t a problem with subcontractors.

Interviewee 4	-Project execution time should starts from the time of signing the contract without any delay. -Contract bidding process took long time and in this project took 7 months. -Contract clauses did not included the communication language with Asian companies that did not follow international technical standards. -Contract clauses did not included milestone communication between the owner and main EPC contractor. -EPCM type of contract has many change ordered.
Interviewee 5	-There was a delaying in contract award caused a project delaying. -The main contractor and contract caused serious problems. -We had two kinds of contracting strategies which were EPC and EPCM contracts. -In EPC contract, the full risk lays on the contractor but we can’t change any order after we signed the contract. -In EPCM contract, the design was the responsibility of the contractor and in cause of delivery delay, it could cost us many things.
Interviewee 6	Contract strategy is essential and must be considered to avoid project lifecycle problems.
Interviewee 7	Yes it was effective but facing some difficulties.
Interviewee 8	-Most of the new complex mega-project contracts in this country are EPCM or EPC contracts. -For services and small jobs EPC or LSTK were preferred in this country. However the drawback of LSTK was the price fixed and we could not change order after signing the contract. Moreover the owner could not interfere in the contractor work. -The cost of change order in EPC/ LSTK contract higher than change order cost for EPCM contract. -We had two EPCM contracts with leading companies to build Smelter and battery limits, two EPC contracts for mine and refinery and one LSTK contract for roll milling. -Traditional procurement contract system was not effective due to the Interests and relationships that affect the decision-making. -Contract award focused on the lowest price.
Interviewee 9	-One of the major risks that we had faced in this project is the EPC/ LSTK contractor who declared bankrupt in the middle of construction phase.
Interviewee 10	-The Mega-project design packages were distributed among three companies and under the supervision of the main contractor. -The cost of smelter project was so high, therefore EPCM was the best contract type.

	-Contracts prices were high. -Salary contracts of expert engineers were high. -Contractors spending forecast was important for project in order to estimate project cost. -Project cost estimation changes depended on the kind of contract. When the company changed orders or changed the scope for a new project view that cost it a fortune but they needed it.
Interviewee 11	-EPC contract has part of project operation responsibility. Mechanical completion usually have delayed for this sort of contract.
Interviewee 12	-Contract characteristics: • Don't squeeze contract. • Money-wise. • Schedule-wise. • Project builds within -+10 of the project time.
Interviewee 13	No answer were given.
Interviewee 14	-For project success board executives must considered the right people, contract type, contractors and subcontractors. -Contract award based on the low bidder price.
Interviewee 15	-We use two major contract EPCM/EPC and unit rate contract. -EPC contract: general in this country, performance guaranteed but it needs well study and risk registry. -EPC/LSTK contract costs more but with law risk and low labor cost. -EPCM/LSTK contract: it needs a full project details. It has project supervision with high labor cost. -Unit rate contract: when the scope unknown like engineering rate and the quantity not estimated. -Performance guarantee is an important clause which must be contained in the contract before you sign it. -Project liability is shared between EPC contractor and the owner. -The most Important contract clauses for mega-project are: Performance guarantee. Governor Law. Attribution rule. Insurance. Acceptance and testing. Change in market. Variation procedure. -Factors are affecting on type of contract are: Time. Team. Market, i.e. booming. Location. Weather. Quality.

4.2.4 Basic engineering design and detailed engineering design phases

Table (4): Responses

Table 4.7: Responses to basic engineering design and detailed engineering design phases

4. Had you ever faced difficulties during design stage or Front-end Engineering design? And why?	
Interviewee 1	Yes, because of design contractor, the main contractor and lack of internal technical expertise.
Interviewee 2	-Yes, design was the second most important phase for the project after calculating ore quantities, it took a long time since we implemented it on three stages for the basic engineering and it needed design confirmation. -Due to the limitation of project management team, we faced problems in basic design during the prefeasibility phase which led into many problems of detailed engineering during the feasibility phase. -Contractor/designer caused the design problem. -Lack of technical expertise increased the chance of design problems. -The allocation for front end engineering, design and planning from overall capital cost of the project was 30%. -It is important for basic engineering and detailed engineering to use value engineering. -Contractor handled everything since most of the project contracts were either TLSK or EPC. However we still did three stages of design review with the contractor. -It is extremely important to have accurate weather information before doing the design phase. -Technology provider, design firm and project team were responsible for conducting design changes in the initiation phase. -Lack of internal value management team caused design problems.
Interviewee 3	-We needed a strong project management team to follow up the design phase with the awarded design company, schedule and time.
Interviewee 4	-Yes we had many design problems due to shortage of project management team that follow up design process with contractor offshore. -Design process took long time.
Interviewee 5	-In EPCM contract, the design is one of the responsibilities of the contractor and in case of delivery delay, it cost us many things. -Design problems and modification caused a delaying a call of construction bidding. -There were many consequences of delaying the contract award especially at the design stage.

	-Design company cut corners and copy paste old projects without review the bid conditions. -Design company rushed everything up to submit the design during the time frame which was took three months. -Design company did no plan the design properly during biding time. -Value management was important for design stage but needs qualified people to evaluate the value of the items not reducing the cost. -Value engineering workshop done after receiving the design from the contractor and implemented on three stages. -There were internal value management team and external value team (consultant) including the contractor or the designer.
Interviewee 6	No answer were given
Interviewee 7	No answer were given
Interviewee 8	-Yes, we have 40 detailed engineering packages in different times and 50 million man hours. -We faced many design problems. -The allocation for front end engineering, design and planning from overall capital cost was 10%. -Usually the design phased take long time due to many complicated factors and in our mega-project it exceeded the expected time. -We used value engineering for the design stage in the prefeasibility phase. -Construction team input and experience needs to be taken into consideration during the design phase. -It is important to have accurate weather information for design and after project start-up phase especially with the changing of weather globally (Global warming). -Design modification was the responsibility of the project management team and main contractor. -Construction, operation and maintenance teams must be in the loop of information of design from the early stage of the project.
Interviewee 9	Design packages had distributed among the three companies and under the supervision of the main contractor.
Interviewee 10	No answer were given
Interviewee 11	Any problem happened during the basic engineering or frontend engineering design phase resulted in an impact on detailed engineering.
Interviewee 12	No answer were given.
Interviewee 13	No answer were given.
Interviewee 14	All stakeholders input and feedback, experience were needed and essential for design phase and it must be immediately after signing the contract.
Interviewee 15	No answer were given.

4.2.5 Software and tools at the project early stages

Table (5): Responses

Table 4.8: Responses to software and tools at the project early stages

5: Did you use software/tools in the project early stages?	
Interviewee 1	We had a mining software program but it was not accurate and the main contractor took the charge to calculate the quantity and quality of raw material.
Interviewee 2	-Mining software program to calculate the ore, designer/contractor provided the project with 3D simulation software program for construction and buildings and AutoCAD. -There were many barriers that hinder use of software tools within the project. -Mining software programs were very expensive. -We faced difficulties due to inaccurate raw material information and inaccurate software programs/tools. -We need accurate and reliable cost estimation software programs in the mining field. -We need for a User-friendly mining software programs.
Interviewee 3	-AutoCAD, 3D design, value management tools, risk tools, cost estimation tools. -We had problem with the financing program.
Interviewee 4	Quality tools, AutoCAD, cost estimation tools, value management tools, risk tools.
Interviewee 5	3D simulation program provided by the designer, AutoCAD, value management tools, cost estimation tools.
Interviewee 6	Risk tools, mining tools, and Financial tools.
Interviewee 7	Cost estimation tool is the most important tool for decision maker during project lifecycle.
Interviewee 8	-Various tools and programs. The technology licenser or nominated design company for example provided the project with 3D simulation design. -We had 'Monte Carlo' simulation program for a cost risk quantitative analysis and to show possible outcome. -'Risk registry' also is a way to divide the whole project into small parts then identify possible risks. -The problem of using software program was the involvement of many players (stakeholders) with different software programs. -The cost of software programs or project tools was relatively very small compared to the overall project cost. -'Matman' is Fluor system for tracking procurement of mega-projects.

	-Drawbacks of using software programs are data require to be maintained regularly, otherwise the tool will not be effective. -Benefits of using software programs are that all of the information is available at the press of a button. -Cost estimation accuracy was the main tool to track the project specifically during the construction phase.
Interviewee 9	Variant tools in every technical and non-technical discipline.
Interviewee 10	Cost estimation tool is the benchmark which is the comparison and market study.
Interviewee 11	-The accuracy of feedstock or ore deposit quality and quantity should be very close to actual cost. Therefore we need accurate software/tool in the mining field. -For mining sector, banks want proven document for the quantities of raw materials and project life expectancy.
Interviewee 12	Traditional project management tools were sufficient to implement the project such as PowerPoint slides, project cost estimation and project daily follow up. However we still need an accurate ore quantity tools.
Interviewee 13	No answer was provided
Interviewee 14	-We have a well-equipped company with all the needs that assist the departments to making decisions. -Yes, the contractor provided 3D building modelling at the concept and prefeasibility stage. We used AutoCAD, mining software programs, financial tools, risk tools, cost estimation tools. -The cost of software programs is high but If we measured the cost of tools on the size of the project then it considered low -Profit and cost estimation are the most important thing for any business. -Therefore directors must have the accurate information to make their decision, measure the gross margin, making optimal choices and valuing the assets based on it.
Interviewee 15	-Negotiation is the tool of the contractual strategy. -Procurement tool was one of the contractor main responsibilities and used to track procurement at construction phase.

4.2.6 Value engineering or value management at the design stage

Table (6): Responses

Table 4.9: Responses to value engineering or value management at the design stage

6: Did you use value management in your organization during prefeasibility stage? If so, how did you use it?	
Interviewee 1	We used value engineering and we have value engineering standards.
Interviewee 2	-Yes, indoor and outdoor teams. -We used it during the three stages of engineering design.

	-It is an important tool for basic engineering and detailed engineering.
Interviewee 3	No answer was given.
Interviewee 4	Value management team had a lack experience in value engineering.
Interviewee 5	-Value engineering workshops did after the design on three stages to evaluate project items/functions with best cost. -Value engineering for design review was important but it did not included the whole stakeholders. -Value engineering workshops covers economic parameters.
Interviewee 6	No answer was given.
Interviewee 7	No answer was given.
Interviewee 8	-Yes, 51% to 75%. -It is an important for the mega-project and we used it from the early stages of the project lifecycle to reduce the cost and increased the value of the items function. -We used it starting from the design phase. -Value management tool was workshops.
Interviewee 9	No answer was given.
Interviewee 10	No answer was given.
Interviewee 11	-Value engineering evaluation was a hurdle for projects. -Value engineering workshops should be value focused not cost cut. -Value engineering should improve and optimize the project items.
Interviewee 12	No answer was given.
Interviewee 13	No answer was given.
Interviewee 14	-As a business unit we don't use it. -As a new company we need to work closely with expert people in every field both internally and externally especially during prefeasibility and planning stages.
Interviewee 15	No answer was given

4.2.7 Mega-engineering project; cost estimation

Table (7): Responses

Table 4.10: Responses to Mega-engineering project; cost estimation

7: Could you evaluate type of accuracy and reliability of cost estimation and technique?	
Interviewee 1	No answer was given.
Interviewee 2	-We needed an accurate and reliable cost estimation for mine and mine equipment to construct the project. These information needs accurate resources, budget and expertise to make decision. Without the accuracy of cost estimating the project will face difficulties.

	-Cost estimation technique was effective and it was one of the responsibilities of the main contractor.
Interviewee 3	No answer was given.
Interviewee 4	No answer was given.
Interviewee 5	Delay of submission of project design packages from the contractor caused an increased in project cost.
Interviewee 6	No answer was given.
Interviewee 7	-Monthly cost estimation (under or over) was one of the most important parameters to measure the progress of mega-project. -Project owner should provide the main mega-project contractor (EPCM) with a monthly cost estimation as a reliable benchmark.
Interviewee 8	-Cost estimation accuracy is the main tool to track the project specifically during the construction phase when many contractors involved in the construction activities. -At the beginning of project life cycle we used previous project cost estimation report for items, technology and accurate cost estimation for the ore. -The cost of mega-project was too high. -The cost of change order in LSTK contract higher than change order cost of EPCM contract. -Project cost overrun happened due to the lack of higher authority cooperation. -Monte Carlo simulation is a cost risk quantitative analysis to show possible outcome
Interviewee 9	No answer was given.
Interviewee 10	-CEO wants to see cost estimation report every six months before the construction phase and fortnightly report during the construction activities to avoid any over cost due to change order. -During construction activities, the contractors were the main source for cost estimation. -If all the projects that belongs to a mega-project started at once it could cause cost inflation in prices. -Project cost estimation depends largely on the information that provided by the project directors, and project director. In return directors and project director depends on contractors spending forecast to estimate project cost during the construction phase. -Change of cost estimation depends on the type of the project contract. -Project Cost estimation tool was the comparison and market study. -One of the responsibility of the main contractor was reviewing the project cost. -The cost of the contractors was high due to the site condition. -The aluminum low prices globally which happened recently caused to shut down many smelters around the world due to the costs prohibitive to this kind of project and due to the rising of energy prices.

Interviewee 11	No answer was given.
Interviewee 12	-Cost estimation from previous projects is suffice for prefeasibility study. -We used regular cost estimation during project lifecycle.
Interviewee 13	
Interviewee 14	-Profit and cost estimation are the most important thing for any business. Therefore directors must have the accurate information to make their decision, measure the gross margin, making optimal choices and valuing the assets based on it. -Using accurate cost estimation helps us to see project details and manage the projects successfully by assigning resources, build schedule.
Interviewee 15	-The accuracy of mining ore cost should be very close to actual cost. -EPC contract costs more and with low labor cost. -EPCM/LSTK contract had a high labor cost.

4.2.8 Mega-engineering projects; function analysis

Table (8): Responses

Table 4.11: Responses to Mega-engineering project; function analysis

8: What methods did you use to carry out the project during the conceptual and prefeasibility phases? , and time used to implement it?	
Interviewee 1	No answer was given.
Interviewee 2	-Meetings and workshops. -We spent 30% of project time during early stages on function analysis. -We had cases that did not used function analysis and we discovered that during construction phase. However with or without function analysis we had to a find way out to take the project to the next level especially during construction phase. -Numerical analysis and data evaluation were the techniques used to compare the alternatives.
Interviewee 3	Financial model analysis should be around +-10 before send it to project management department.
Interviewee 4	No answer was given.
Interviewee 5	Cost evaluation workshops of project items or project functions had done after each stage of design phases.
Interviewee 6	No answer was given.
Interviewee 7	No answer was given.
Interviewee 8	-Workshops varied according to the needs of the project. -the percentage of time we did spend on function analysis was 26% to 50% in the early stage. -Sometimes external stakeholders and project objectives dictate requirements that have to be met regardless of the analysis.

	-Life cycle cost models were one of the project function analysis. -Comparative evaluation were the technique used for function analysis to compare the alternatives.
Interviewee 9	No answer was given.
Interviewee 10	No answer was given.
Interviewee 11	By comparison of previous items.
Interviewee 12	No answer was given.
Interviewee 13	No answer was given
Interviewee 14	Workshops.
Interviewee 15	No answer was given.

4.2.9 Mega-engineering project; team during conceptual or initiation phase

Table (9): Responses

Table 4.12: Responses to Mega-engineering project; team during conceptual or initiation phase

9: Who, generally, was responsible for carrying out the project during conceptual/initiation and planning phases?	
Interviewee 1	Project execution team managed by two authorities.
Interviewee 2	-We had teams under the management of contractors for design, to collect the raw material data and for project construction. -Internal Project team, technology provider team and design contractor were responsible for conducting the design changes. -Our project management team was very small. -As an operation company, we needed operators and people to run the project after construction phase. However the main contractor teams handled the project activities from concept to execution phase under our supervision. -The prefeasibility and planning stages were conducted by an external team due to the lack of an expert internal project management team in the design, value management and supervision. -We did not have a design team. -Technical teams, all contractors, construction team, operation team and maintenance team should be part of the design change team at early project stages. -Most of the teams did not have the mining background knowledge and terminologies.
Interviewee 3	A strong engineering team to follow up the design and schedule is important for some kind of contracts such as EPCM contract.
Interviewee 4	Internal project management team had a lack experience in engineering design and value engineering.
Interviewee 5	No answer was given.

Interviewee 6	Operation team did not participated with the internal and external project teams in the design phase at the early stage of the project.
Interviewee 7	No answer was given.
Interviewee 8	-We had five main international contractors for each project and one of them was the project team leader. -Design changed were one of the responsibilities of internal and external project management team and the main contractor. -80 to 120 person were representing the project management team at the construction phase. -It is very important to have expert engineers in every field during the mega-project life cycle and especially when you have to deal with many companies, contractors and different authorities. -Our project was a new, complex and unique and we had neither the technology nor the experience to run such a mega-project. -We had a massive mega-project and seriously we had a lack of team work during the construction phase. -Design team must be in the loop of information with construction and operation from the early stage of the project. -All parties and departments such as engineering, construction management, operations and maintenance must joined design team. -Project team had impacted on the effectiveness of project and process.
Interviewee 9	No answer was given
Interviewee 10	We worked with five companies and every company had a project team that represented the owner and main contractor, and all of the five projects teams were working under the instruction of mega-project main contractor.
Interviewee 11	No answer was given.
Interviewee 12	-Project management teams were technical and non-technical. -Honesty and integrity of team members and top management are important to implementing the projects. -Teams members most make everything simple and then follow it up.
Interviewee 13	-Mega-projects attracted expertise more than money. They need to fill up their C.Vs with broad experience.
Interviewee 14	-Project management team is very important due the newness of the industry in the country. -We had many projects with different sizes in each subsidiary. -We had external project management team but internal to the owner. -As a new company we need to work closely with expert people in every field both internally and externally especially during prefeasibility and planning stages. -It is very important for any business to have expertise in every department.-
Interviewee 15	No answer was given.

4.2.10 Mega-engineering project; market condition and external factors

Table (10): Responses

Table 4.13: Responses to Mega-engineering project; market condition and external factors

10: How did you evaluate the market condition and external factors during project early stages?	
Interviewee 1	-We driven by market and have a long-term product.
Interviewee 2	-We are a national gold company and don't have competitors locally. -It is extremely important to have the mining ore and financial support and without them we cannot do anything. -Government regulation and authorities support may either hinder the progress of the project implementation or boost it. We faced difficulties in this matter especially in obtaining licenses and manpower systems.
Interviewee 3	Subcontractors and shortage of manpower were another hurdle that faced the project due to the regional market booming.
Interviewee 4	Market booming caused a mobilization difficulties to remote area for the contractors.
Interviewee 5	-Due to a regional market booming in construction, the company faced obstacles in finding: -Construction companies. -Subcontractors. -Fabricators. -Manpower such as discipline engineers and project engineers -Qualified experts in mining field to supervise and managing new projects. -Due to a regional market booming, we were forced to deal with Asian companies due to the engagement of large international construction companies with another local and international contracts. -Most of the construction activities face delaying because of the shortage in qualified manpower.
Interviewee 6	Contractor lack of local market knowledge of contractor caused project delay.
Interviewee 7	Our company is an operational company that driven by opportunity and we have a long-term product.
Interviewee 8	-We don't have a local competitor since it is a new industry in this country. -Building up a massive mega-project that contains plants, roads, buildings, train, sea port, electric energy was in need to massive resources in every field such as human, technology, ore, financial and so on from the beginning of concept phase until delivering the final product. -Government regulation was very important and could cause a serious problem especially at the beginning of the project and in the mid of construction phase. -At the beginning of the project we had problem with issuing the project licenses and the interface problems with four or five authorities around the project location, and in the mid of the project the government change the labor law and

	this decision caused a serious problem for our subcontractors during the construction phase. -Authority cooperation had impacted on the project progress. -Political stability is an extremely important for new industry and especially for mega-project. -Political stability is very important for the company that does not own the technology and have expertise.
Interviewee 9	No answer was given.
Interviewee 10	-Market study was an important for cost estimation. -Market booming led to increase contracts price.
Interviewee 11	No answer was given.
Interviewee 12	No answer was given.
Interviewee 13	Mining projects were a new market for this country.
Interviewee 14	-Mining company owned by 50% public and 50% government. -We are a mining company and listed in the stock exchange market, we have the natural resources and the support of the shareholders. Therefore we are working now on building up our name and brand. -We have an international competitors for all of our products and we work with them to support our product and to find a foothold in the global market. -Regarding the products we have our market and marketing system to distribute our product around the world. -Government regulation and cooperation are an extremely important to implement projects. -Economic and political stability of any country is a major catalyst for international companies, investors and expertise.
Interviewee 15	-Change in market was one of the most important contract clauses for mega-projects. -Market was one of the factors that affecting on choosing the type of contract.

4.2.11 Mega-engineering project; location and logistics

Table (11): Responses

Table 4.14: Responses to Mega-engineering project; location and logistics

11: Could you evaluate the project location and logistics?	
Interviewee 1	-We had location utility problems, logistics and mobilization as well
Interviewee 2	-We faced serious difficulties with the location, utilities, logistics and mobilization of manpower to the location.

	-The location of the project and logistics were two of many factors that affected on the success of the project.
Interviewee 3	No answer was given.
Interviewee 4	No answer was given.
Interviewee 5	No answer was given.
Interviewee 6	The major risks of project construction in mining field were project location (remote area) and the logistics.
Interviewee 7	No answer was given.
Interviewee 8	-Our project was an integrated complex (from mine to port) located in the remote area and lacks all the necessities of life. -The mine also located far away from the location of plants and sea port. We faced risks and difficulties in everything from roads to electricity to water to manpower and so on. -Logistics and facilities were one of the factors that affected on the success of the project.
Interviewee 9	-We had faced communication hurdles with the herders or the indigenous people who had considered as the neighbor of the project. -we had faced interface difficulties with five governmental authorities around the project location and resulted in to bear an additional expenditure on the project during the construction phase. -Location licenses
Interviewee 10	No answer was given.
Interviewee 11	No answer was given.
Interviewee 12	No answer was given.
Interviewee 13	No answer was given.
Interviewee 14	-It is extremely important to have a project next to the facilities and resources, but in mining project all of the ore located in the remote areas.
Interviewee 15	Project location affected on choosing contract type.

4.2.12 Mega-engineering project; linguistic diverse and internal culture

Table (12): Responses

Table 4.15: Responses to Mega-engineering project; linguistic diverse and internal culture

12: How did you evaluate culture impact on the project progress?	
Interviewee 1	We faced communication difficulties with Asian companies.
Interviewee 2	-The culture within the organization during the product development stage is a very important factor in project success. We worked closely with different international companies that has different languages and cultures. The contract and international technical standards were the sole communication language. -It is important to set up management plan in the workplace for project culture diversity especially when you deal with contractors and subcontractors in a remote area. -The communication language during the project implementation must be the international technical and non-technical standards. We faced communication

	difficulties to deal with Chinese and Korean companies since they were not dealing with these international standards.
Interviewee 3	No answer was given.
Interviewee 4	Asian companies had English language barrier and understanding international technical standards.
Interviewee 5	Facilitate communication with other departments and contractor was one of the owner responsibilities.
Interviewee 6	No answer was given.
Interviewee 7	No answer was given.
Interviewee 8	-Cultural Factors had impacted on the effectiveness of project process due to the diversity of work, companies, contracts and projects teams. -Internal company culture had positive or negative impacts on the project progression when there are many contractors, subcontractors, vendors, suppliers and fabricators involve from all over the world. However since most of the people who worked for this project were expertise, the impact was positively except in communication between departments.
Interviewee 9	No answer was given.
Interviewee 10	No answer was given.
Interviewee 11	No answer was given.
Interviewee 12	No answer was given.
Interviewee 13	No answer was given.
Interviewee 14	-We had dealt with different companies, countries and worked based on the international standards. -Culture diversity is important element for our company since we have different products and projects, and we are in need to expertise in different fields.
Interviewee 15	No answer was given.

4.2.13 Mega-engineering project in the mining field

Table (13): Responses

Table 4.16: Responses to Mega-engineering project in the mining field

13: What is the mega-project and did your mega-project have a clear theoretical and professional image?	
Interviewee 1	-We have 8 mining projects. -Cost and size define the mega-project. -Our mega-project theoretical image was not clear
Interviewee 2	-You can visualize meg-project but it's hard to implement it without the support of the technology providers. -Difficulties, technology used, and budget can defined the mega-project. -Meg-project was driven by technology, experience and professional people in the mining field.

	-Mega-project in mining field measured by mineral resource (ore) and project definition. -Project delivery type was just-in-time delivery and parallel workflow models.
Interviewee 3	No answer was given.
Interviewee 4	No answer was given.
Interviewee 5	No answer was given.
Interviewee 6	No answer was given.
Interviewee 7	No answer was given.
Interviewee 8	-Our Aluminum project capital cost was $10.8. -The image of mega-project stays ambiguous if we don't have experts and leading companies in the same field. -Mega-project can be defined by the size of the project, parties involved, capital project and technology involved. -Mega-project driven by engineering expertise. -Mega-project in the mining field at early stages measured by availability of resources, project scope and weekly monitored to adjust and any deviation from baseline. -Our project delivery used project management sequential.
Interviewee 9	No answer was given.
Interviewee 10	Project budget was 10.8 billion dollar.
Interviewee 11	No answer was given.
Interviewee 12	No answer was given.
Interviewee 13	No answer was given.
Interviewee 14	-We have around 10 projects some are mega-project and some are major projects. -Mega-project in mining field is not always as glorious as people think it is.
Interviewee 15	No answer was given.

4.2.14 Mega-engineering projects; leadership

Table (14): Responses

Table 4.17: Responses to Mega-engineering project; leadership

14: How did you evaluate the impact of leadership on the project progress?	
Interviewee 1	Authority and organization chart affected on the project progression.
Interviewee 2	-Higher management approval during design phase caused project delay. -We had lack of communication from top to bottom.
Interviewee 3	Project owner was the main caused for project delay.
Interviewee 4	-Top management approval took long time especially for design evaluation. -There were a lack of understanding between higher management and project teams.
Interviewee 5	The higher management did not assigned the authority matrix for project team properly.
Interviewee 6	No answer was given.

Interviewee 7	No answer was given.
Interviewee 8	-External and internal authority cooperation impacted on the project success. -Lack of clarity in regular communications spike the number of meeting requests and waste stakeholders time. -Lack of authority cooperation caused project cost overrun.
Interviewee 9	-Project permits consumed long time to get ready by the external authorities. -Any project interface is a major risk, and in this mega-project we had five interfaces with governmental authorities. It took us three years to reach to agreement with only one authority.
Interviewee 10	No answer was given.
Interviewee 11	No answer was given.
Interviewee 12	-Leadership must refrain from squeezing contract conditions. -Leadership protect the resources and spend money-wisely. -Leadership must plan project schedule-wisely. -Leadership must considered the construction time allowance within -+10 of the project time. -Planning must be simple. -Leadership must follow up the project plan on daily basis. -Leadership must have honesty and integrity.
Interviewee 13	Leadership must avoid change management by define project and jobs properly.
Interviewee 14	-Stakeholder communication is very important and there is a plan for communication but need to activate.
Interviewee 15	No answer was given.

4.3 Summary of Interviewee Questions and Responses

The following tables represent summaries of the questions that given to the interviewees of the gold subsidiary, the aluminum subsidiary and the headquarters, and their responses

Table 4.18: Interviewee question and response from QI to Q4:

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
QI	**What was your position?**														
	President of Gold subsidiary & vice president of company	Director, new gold mines Devel , Gold subsidiary	Gold project director & execution, Gold subsidiary	Manager, projects & ENGR & QA/QC, Gold subsidiary	Mining project manager, Gold subsidiary	Manager, project control & risk mgmt, Gold subsidiary	President of Aluminum subsidiary	Program deputy project director, Aluminum subsidiary	Program deputy project director, Aluminum subsidiary	Financial planning & analysis manager, Aluminum subsidiary	President of petro-chemical company, partner of Aluminum subsidiary	GM planning & Devel , partner of Aluminum subsidiary	VP of project mgmt & ENGR Headquarters	VP of corporate control & enterprise Risk, Head-quarters	Director Contract& procurement, Head-quarters
QII	**How many years of work experience do you have?**														
	25 years	15 years	18 years	17 years	16 years	14 years	30 years	20 years	20 years	14 years	27 years	34 years	34 years	29 years	26 years
QIII	**Which sector do you have the most experience in?**														
	Mining	Mining	Petro-chemical	Petro-chemical	Petro-chemical	Petro-chemical	Petro-chemical	Mining	Petro-chemical	Mining	Petro-chemical	Petro-chemical	Oil and Gas	Oil and Gas	Mining
QIV	**What is your company affiliation?**														
	Gold	Gold	Gold	Gold	Gold	Gold	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Headquarters	Headquarters	Headquarters
QV	**Are you client or partner?**														
	Client	Client	Client	Client	Client	Client	Client	Client	Client	Client	Partner	Partner	Client	Client	Client
QVI	**Is your company public or privet?**														
	Public	Public	Public	Public	Public	Public	Public	Public	Public	Public	Privet	Privet	Public	Public	Public
Q1	**What is the capital investment of your mega-engineering projects?**														
	One mine only was cost 500 million dollar	Variant capital cost for 8 mines each one has its own facilities	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	$10.8 billion dollar for an aluminum complex	Buildings, piping system, roads, security system, fence, roll milling, smelter, refinery & mine	$10.8 billion dollar for mine, refinery, smelter, roll-milling, sheets & battery limits.	750 million dollar	750 million dollar	No answer was given	We had 10 projects some were mega-project another were major projects	No answer was given
Q2	**What is your company type?**														
	Operational company, driven by market, long-term product	Operation company	Operation company	Operation company	Operation company	Operation company	Operation company, driven by opportunity , has long-term product.	It is an operational company.	Mining operation company	Mining operation company	Petrochemical company owned by 50% privet & 50% mining company	Petrochemical company owned by 50% privet & 50% mining company	Operation company	Mining company owned by 50% public & 50% government	Operation company
Q3	**Did the Mega project have a clear theoretical base?**														
	We had a lack of theoretical image of megaproject	I didn't think so	It was hard to visualize project process at early stage	Undecided	Undecided	Undecided	No it was not clear. -We had used traditional PM process to implement it	Not always, it is different from sector to another but with same activities and process.	Undecided	Undecided	No	No	No	No	Undecided
Q4	**Did the Mega project have a clear professional image?**														
	Not before the prefeasibility phase.	You can visualize it but hard to implement it without the help of the technology providers.	Undecided	Undecided	Undecided	Undecided	No since there were a lack of expertise and technology at the project early stages.	-Without experts & leading firms the image of mega-project stays ambiguous -Resources, scope & monitoring can measure the project.	Undecided	Undecided	No	No	No	Not always as glorious as people think it is.	No

Table 4.19: Interviewee question and response from Q5 to Q11

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q5	**How do you define the Mega project?**														
	By cost and size	By difficulties, technology used, and budget.	No answer was given	No answer was given	No answer was given	No answer was given	By size and cost	By size of the project, parties involved, capital project and technology involved	No answer was given	No answer was given	Cost	Cost	Cost and size	Cost and size define the mega-project.	No answer was given
Q6	**Was the Mega-project driven by practice only?**														
	No, it was driven by market. -we had 8 mining projects	I think by technology, experience and expert in the mining field.	No answer was given	No answer was given	No answer was given	No answer was given	Technical experience	By technical expertise.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Somewhat agree with this statement	No answer was given
Q7	**Which process did your company follow in the early stages of the project?**														
	-Traditional project management. -Stage-gate process for the design phases evaluation at basic & detailed engineering	-Stage-gate process for design phase. Traditional PM for the rest of the phases due to the limitation of project management team.	Stage-gate for design process -No technical team to follow up the design phases properly.	-Stage-gate process for design evaluation with the designer -It had Covered economic parameters such as IRR, ROI & MPV, value engineering , HAZOPS and operability study.	Stage-gate for the design process	Project management process.	Project management process and stage-gate process.	-PM process in the concept phase -The stage gate process for design & planning instead of traditional PM	No answer was given	Traditional project management	Project management	Project management process	Project management to manage technical and nontechnical activities and stage-gate process for design	Project management and now moving toward stage-gate.	No answer was given
Q8	**Types of mega-project contract at the early stages of the project?**														
	Either EPC or EPCM	-EPC contract - EPC/LSTK -EPCM contract - EPCM/LSTK	EPC or EPCM contracts	EPC or EPCM	EPC or EPCM	EPC or EPCM	EPCM or EPC	2- EPCM 2- EPC & 1-EPC/LSTK for services and small projects. -Cost of change orders in the EPC/LSTK higher than EPCM due to the fixation of the price.	-EPC OR EPCM - EPC/LSTK contractor had declared bankrupt in the middle of the construction phase	-EPCM or EPC -The type of project contract affects project cost estimation	EPC and EPCM contracts	EPCM and EPC type of contract	EPC or EPCM	Depends on many factors, in general EPC and EPCM	-EPCM -EPC -Unit rate when project scope is unknown
Q9	**Type of project delivery?**														
	Project management process except the design phase	Just-in-time delivery and parallel workflow models	Project management process	Project management way	Project management	Project management	Traditional project management process and stage-gate process	Project management sequential activities	Project management process	No answer was given	Project management process was effective for our projects.	Project management and it was useful tool for our operation medium-sized company.	Project management process	Sequential traditional work	No answer was given
Q10	**Had you ever faced difficulties to execute Megaprojects in the initiation phase?**														
	Yes, design on three stages, contractor selection.	Yes at completion of conceptual phase, preparation for design. -Technical team -Evaluation time	Yes, the PM had a lack of design experience - unprofessional designer. -lack of enough time for design evaluation	Yes, a lack of professional technical team during the design phases -design evaluation time was short - maintenance and operation teams did not involve in the design evaluation	Yes, many -No technical team in the design phases. -Contractor -evolution time of design items was not enough -operation team did not participated in the design phases	Operation & maintenance teams had not been involved in design evaluation workshops.	Yes, he stage-gate process and the need to link the stage-gate process to the right discipline or department and team.	Yes, preparation for everything from scope definition to design to bidding.	No answer was given.	Yes, many with the contractors, material prices and market booming.	Yes	Yes	Yes at any starting point there is always a difficulties and we had a lack of expertise.	Yes, project main contractor, biding, contract awards, government regulations.	The performance guarantee, governor law, attribution rule, insurance, acceptance of conditions, testing of technology, change in market and variation procedure
Q11	**Had you ever faced difficulties during detailed design engineering?**														
	Yes stage-gate approval	Yes, During basic design which leads to many problems of detailed engineering . -Stage-gate design approvals	Our problems had occurred in the design phase	Yes design evaluation and design approval had took long time to evaluate by the high management	Yes , lack of allowed time for evaluation preparation by the owner to the internal project members	Yes	Yes and happening always for the most of projects.	Yes, we had 40 detailed design packages and 50 million man hours. -Problem of basic and detailed design, change order or scope change.	Yes many difficulties and problems	Yes, design packages had been distributed among the three leading companies and under the supervision of a leading contractor	Always	Yes and we had to reviewed everything the designer.	Yes and most of the projects if not all of them had faced difficulties at the detailed design.	For sure yes but you can ask the technical team.	No response was given

Table 4.20: Interviewee question and response from Q12 to Q18

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q12	**How many times did you change the scope of work?**														
	Once or twice a month for 22 months project	Many times	Many times during the design phases	A lot	Many times	Many times	We had seen it every month	More than 5 times during construction phase & many during basic engineering.	Many times	It had happened many time.	Unstoppable issue	It is an ongoing problem for every project	Many times.	No answer was given	No answer was given
Q13	**How do you evaluate the scope and the scope creep?**														
	It is hard to stop it and we had tried to minimize it.	Scope creep had raised due to the basic design faults. We did spend a lot of time and money during this stage.	The owner was the main source of the project scope creep.	The design and constructio n phases full of scope creep	We had faced it a lot during the project lifecycle	Most of the project risks considered as a scope creep sources, we had tried to control it,	No answer was given	Change order had appeared after award of contract & was a tool to show scope creep.	Design and contractor were the reason behind scope creep and due to lack of internal technical team. -Lack of government cooperation	-Design deficiency -Change project phase from constructio n to operation had caused the scope creep & cost overrun -Unstable supply of utilities -Inaccurate raw material calculation -Inaccurate cost estimation information from the main contractor during the constructio n -Owner	The owner, project designer, contract agreement, accuracy of feedstock calculation & main contractor were the main reason for scope creep due to a lack of internal technical team. -Transfer the project from construction phase to startup phase had caused scope creep and extra cost due to the contract agreement -Utilities -Bank loan delay	-Contract agreement with the owner, contract agreement with the technology provider & amended project scope by the owner caused scope creep. -We had faced deficiency with the design at the project early stages due to lack of internal design team. -Board members' approval	-Happened due to delay of project loan. -Imposition of board members decisions on the company strategy and on an award contractor.	No response was given	No response was given
Q14	**What is the percentage of allocation for front end engineering, design and planning from overall capital cost?**														
	No response was given	30%	No response was given	No response was given	No response was given	No response was given	No response was given	10%	No response was given	No response was given	No response was given	No response was given	No response was given	No response was given	No response was given
Q15	**What measures did mega- project at early stages need to take to improve project performance and avoid project life cycle problem?**														
	Well project definition	Measured mineral resource (ore) and well define project and scope.	No response was given	No response was given	No response was given	No response was given	Good design and local mining contractors and suppliers	Well defined scope and realistic schedule backed up with true available resources, and monitored weekly to adjust and remedy any deviation from baseline.	Contractor who knows the local market	Local suppliers and contractors	If there was a Local designer	Contractor, vendors and suppliers for the design and constructio n	No response was given	Good planning	No response was given
Q16	**How did you rate internal lack of awareness or knowledge about this mining project?**														
	High	Very high among the project new comers who had joined the project team from non-mining industry	High	High	High	High	High since it was a new project	Mining projects were new industry in this country and it was clear we have a shortage of expertise	Very high	High	Extremely high	Very high	Mining projects were new locally	High because it was a new field in the country	No response was given
Q17	**How did you evaluate the support from parties with authorities?**														
	It was not effective enough	There was a lack of support from different parties.	Support was not effective from all parties	Communic ation plan was not proper	The project had a lack of the proper support and communica tion	No answer was given	It was good	Lack of authorities' support was one of the major dilemmas of the project.	We had faced lack of support in different occasions	It had happened in different levels of the project lifecycle	We had faced difficulties.	There were a lack of support in some cases.	No response was given	Authorities were encouragin g all parties but not effectively	No response was given
Q18	**How did you evaluate the importance of the technical understanding?**														
	Very important	With lack of process were the biggest factors caused a gap in our mining projects	Very important	Very important	Very important	Very important	It was very important	The percentage of importance were very high since we had a small technical team.	Extremely important especially in the mining field	We had a lack of expertise at the beginning of the project	Extremely important, we had lack of technical expertise in mining industry	Very important for any project to have technical expertise in the same field.	No response was given	Insufficient technical knowledge is prominent feature everywhere .	No response was given

Table 4.21: Interviewee question and response from Q19 to Q25

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q19	**How did you evaluate the importance of the senior management commitment?**														
	It was so important but had needed to assign responsibilities properly	They were committed but there were a major caused of projects delay	Owner had caused a project delay	No answer was given	No answer was given	No answer was given	-A lack of the project cooperation had happened at the project early stages. -the tax was project time & extra cost	Lack of effective commitment had seriously affected the project delivery from the project early stages.	It's important & there were a lack of commitment from senior management - Lack of cooperation b/w external authorities & internal higher management	.No answer was given	They were committed but we had a lack of communication.	-The leadership must have honesty & integrity. -A lack of spending money-wisely	Very important	It was the most crucial and required during the project lifecycle.	Extremely important
Q20	**How did you evaluate the importance of time to execute the project?**														
	Time is important for any project	Poor planning had led to lag of project activities	Very important	Extremely important	Time means schedule and money	Good project definition and plan are important to avoid project risk	Extremely important for all shareholders and stakeholders	Lack of project understanding during early stages lead to inadequate execution time.	Very important but we were behind the schedule	Very important for project cost estimation, market, construction material, labor, contractors. And so on	Extremely important	Very important	Extremely important	It is one of many causes of project failure in the world of project management.	Very important
Q21	**How did you evaluate the importance of the training in organization?**														
	We had mining short courses training for technicians.	We had a good training program and it is so important for new comers.	Very important especially at the construction phase	Very important	Important	Very important especially for those who had non-mining background	Mining was a new sector and we had needed to train the new comers, operators, technicians	We had a good training budget and without it the employees would cost the company more than the money.	Important for mining field	Very important	Important	Important	Very important and we do that regularly for our employees	Employee training is our way to influence their performance and we spend a lot of money on training.	Very important
Q22	**What factors had affected the success of the projects?**														
	Role and responsibility -project definition -Location -Contractor -Inaccurate mineral calculation	-Location. -Logistics. -Quantity of ore. -Planning. -team members -stage-gate process	-The owner -Project definition -Scope definition -Contract -Design -cost estimation	-Job description. -Project definition -Contractor -team	-Design -Technical team -Contractor -Logistics	-Project risks were: -Contractor -Logistics -project team members -Location	Everything from design to Expertise, to contractors, to startup.	Technology license, logistics, PM team, project definition, utilities, authority cooperation	The project had difficulties to obtain project licenses from the governments	No answer was given	No answer was given	EPC clauses had not considered some conditions and had affected the project started-up phase specifically at the mechanical completion stage	Everything is important for mega-project or any project.	New technology and industry competence had a direct impacts on project success	Time, team, market booming, location, weather and quality
Q23	**How did you evaluate the communication among project stakeholders?**														
	It was not effective as required	We had a lack of it from top to bottom	It plan was not good.	It between parties was not well.	There were a lack of it between contractor and internal project team.	No answer was given	It was good	-Lack of clarity in regular it. A lot of meeting that waste the project time.	There were a lack of it	It needed for reform	It plan was not effective	-The higher management had tried to squeeze the contract conditions. -A lack of simple planning -A lack of daily supervision	There were a lack of job description, project definition and process.	Stakeholder it is very important and there was a plan for it but need to activate.	No answer was given
Q24	**How did you stop project creep from the beginning of the initiation phase and planning phase?**														
	Accurate deposit calculation and good design.	-Calculate ore quantity -Defining the project. -Defining the scope of work properly	The owner and contract strategy were the reasons behind the scope creep.	Proper definition of scope of work	A clear definition of scope of work	Scope creep at the prefeasibility had happened due to lack of follow up the design with the designer.	No answer was given	Well define scope & objectives to be set up from the beginning.	-Design & contractor were the reason behind scope creep & due to lack of internal technical team. -Lack of government cooperation	-Design deficiency -Change project phase from construction to operation had caused the scope creep & cost overrun -Unstable supply of utilities -Inaccurate raw material calculation -Inaccurate cost estimation information from the main contractor during the construction -Owner	The owner, project designer, contract agreement, accuracy of feedstock calculation & main contractor were the main reason for scope creep due to a lack of internal technical team. -Transfer the project from construction phase to startup phase had caused scope creep and extra cost due to the contract agreement -Utilities -Bank loan delay	-Contract agreement with the owner, contract agreement with the technology provider & amended project scope by the owner caused scope creep. -We had faced deficiency with the design at the project early stages due to lack of internal design team. -Board members' approval	-Happened due to delay of project loan. -Imposition of board members decisions on the company strategy and on an award contractor.	No response was given	No response was given
Q25	**Did this project completely achieve the required objectives in the initiation and planning phase?**														
	Yes	Generally, yes	No answer was given	No answer was given	No answer was given	No answer was given	Yes	Yes, most of them did	Yes	No answer was given	No answer was given	No answer was given	Yes	Yes, most of them	No answer was given

Table 4.22: Interviewee question and response from Q26 to Q32

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q26	**How far were you satisfied with implementing projects?**														
	Satisfied	Satisfied	Not satisfied	Not satisfied	Not satisfied	Satisfied	Satisfied	Fairly satisfied	Not satisfied	Not satisfied	Not satisfied	Not satisfied	Satisfied	Satisfied	Fairly satisfied
Q27	**What did you think the main on-going costs are for any given project?**														
	Change order	Change order and scope of work	Change order	Change order	Change order	No answer was given	Change order	Change management and scope creep	No answer was given	Change order	Change order	Change order	Change order	Scope of work	No answer was given
Q28	**How closely did the project adhere to schedule duration of design, planning study in early stages?**														
	There were a lag time in project schedule	-Basic design and then detailed design had consumed the time -It had needed long design process evaluation, & authority approval.	It was behind the plan	Not effective.	-Delay of project design packages submission by the designer had increased the project cost. -Lack of allowed time for preparation of design evaluation by the owner -Lack of time for design bidding plan, design bidding & pre-review time of design	No answer was given	We were behind the schedule since we had faced difficulties at the beginning of the project	Design phase had took long time due to many different factors & exceeded the design deficiencies by the designer	It had exceeded the planned time and some of stakeholders did not participated in the design review.	Very behind	Lack of a proper planning.	A lack of proper project definition, a lack of considering the construction time allowance within -+10 of the project time.	Some projects were behind the schedule	No answer was given	No answer was given
Q29	**Do you think the funding mechanism for the newly constructed mega project was effective?**														
	Inaccurate ore calculation had affected on the funding mechanism	Ore quantity calculation had affected on project loan	No answer was given	No answer was given	No answer was given	No answer was given	The shareholders had fully supported the mega-project	It depended on whether the project was being self-funded by the owners or by other means	No answer was given	Very effective after dividing the project to three project to obtain three different loans from different banks.	Banks want documents stating the quantities of mineral resources & project life expectancy in order to facilitate any loan	The process was so long.	No, mining funding mechanism different than oil and gas funding mechanism	Usually no and there were many factors that affected the funding mechanism.	Different from project to another and it highly depends on the natural resources
Q30	**Did your organization use tools at the early stages before of project planning? If so, what were they?**														
	Yes, software programs to calculate the ore quantity.	Yes, mining software programs, construction tools.	No answer was given	No answer was given	No answer was given	No answer was given	Yes for design, raw material calculation and so on	Yes, variants programs since we have integrated project in one complex. "Matman" was a tool for tracking procurement at construction phase	No answer was given	Yes different tools for each department	-Feedstock accuracy calculation with the help of the main contractor for the project cost estimation. -Software programs were expensive.	The most important part of the project at the early stage was the ore calculation. Contractors did that part.	3D building information modeling at the prefeasibility stage	Yes, 3D simulation software for construction and buildings and another tools for mining ore	No answer was given
Q31	**What were the main barriers that hinder software tools in mega-projects?**														
	Price and manpower	-Capability of use the program. -Cost of long license agreement -Intractable with other systems.	No answer was given	No answer was given	No answer was given	No answer was given	-Project time and cost of the program. -If there were a cost estimation program we could obtained it	Every contractor had its own software programs. However output needs to be in form of report readable by all.	No answer was given	Software programs project very costly.	Price was expensive.	The high cost of software programs	No answer was given	Budget and operators	No answer was given
Q32	**How could these impediments be overcome?**														
	It was hard to find a good program	User-friendly mining software programs.	No answer was given	No answer was given	No answer was given	No answer was given	Agree with the stakeholders and all involve parties about the procedures and tools to be used during the initiation phase of the project.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given

Table 4.23: Interviewee question and response from Q33 to Q39

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q33	**Did you use building information modelling in the concept/initiation/planning phase?**														
	Yes and had provided by the designer	Yes, it was one of a main contractor responsibilities	No answer was given	No answer was given	No answer was given	No answer was given	Yes	Yes, by the technology licenser or nominated design company	No answer was given	No answer was given	Yes	Designer had provided it	Yes	Yes, contractor had provided 3D building modelling.	No answer was given
Q34	**What were the reasons behind the limited use of software tools during early stages?**														
	Prices and operators	-Expensive prices -We had our own software programs and we were dealing contractors in the mining field to calculate the mining ore.	No response was given	No response was given	No response was given	No response was given	No response was given	Every contractor has its own software programs.	No response was given	The price or lack of effective cost estimation programs	Time, price and manpower	Cost and the limitation of project time	No response was given	Business unit had used essential software programs for communic. meeting & decision making such as Microsoft office, AutoCAD & 3D modelling	No response was given
Q35	**How did you evaluate the cost of megaproject software?**														
	Expensive	Low compared to the size and budget of this massive project	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Low compared to the size and budget of this massive project	No answer was given	Expensive	High	High	High and needs for budget & training	Expensive	No answer was given
Q36	**What were the weaknesses and strengths of the software tools approach in the initiation phase?**														
	-Very powerful to calculate ore deposit -Expensive	-Simply without an accurate ore calculation any mining project will face a difficulties -We had limited budget & time to estimate the ore quantity.	No answer was given	No answer was given	No answer was given	No answer was given	Price and operators	It's as good as the data been fed to them.	No answer was given	Price	Time, price and manpower	Cost and the limitation of project time.	No answer was given	It is a technical question & you can ask the IT & technical	No answer was given
Q37	**How did the external team influence software tools use in this project?**														
	Ore calculation and design	Contractors calculate the ore quantity & without it we can't get a loan or execute the project. Contractors calculate the ore quantity & without it we can't get a loan or execute the project.	No answer was given	No answer was given	No answer was given	No answer was given	External teams had handled most of the work.	We had needed the data for the ore at the beginning of the project.	Design, construction and management	We were dealing with 5 leading companies	We outsource most of the project activities	Contractor was responsible about most of the jobs	No answer was given	No answer was given	Contractor responsible about the procurement tracking in construction phase
Q38	**Did you use value management in your organization? If so, how did you use it?**														
	Yes and according to international standards.	Yes, indoor and outdoor teams	Yes for design evaluation	Yes, during the design phases and to evaluate project items with best cost	Yes, to evaluate the project design and equipment function	No answer was given	Yes	Yes, 51% to 75% of the early stages time.	Yes	No answer was given	It consumed the time and it needs for technical expertise.	The main contractor had handled everything under our supervision	No answer was given	Subsidiaries do it at project early stages.	There were agreements with value engineering consultants
Q39	**Did your organization use value management during the concept stage of project life cycle?**														
	Yes and in the design for evaluating HAZOP on three stages	We had used it during design.	During prefeasibility & feasibility phases	No answer was given	No answer was given	No answer was given	No answer was given	Yes, it had used from the early stages of the project lifecycle to reduce the cost & increased the value of the items function	No answer was given	No answer was given	It must focus on adding value not deducting the cost	Not effective.	No answer was given	It used by the aluminum, gold and phosphate projects.	Yes

Table 4.24: Interviewee question and response from Q40 to Q47

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q40	**Did you use value management for design stage?**														
	Yes and we had our own value engineering standards	It was an important tool for basic engineering and detailed engineering.	Yes on three stages and for basic and detailed design	Yes but internal value management team had a lack of experience in value engineering	Yes but we had faced difficulties due to the lack of evaluation time and operations team did not participate in the design evaluation	Yes but not effectively due to lack of participation of the rest of teams in design evaluation	Yes	Yes for all projects starting of the design phase.	No answer was given	No answer was given	yes	Yes, value engineering review with the consultant and designer.	Yes	Yes	Yes, and value engineering consultant companies had participated in the design review.
Q41	**Did you spend money on value management, software tools during the project early stages? Was it cost effective?**														
	Yes we had spent money on external value management consultant and on mining software tools.	Yes, on external value management team and on mining software program with the support of our contractors	Yes on external value management consultant team	Yes	Yes	Yes	Yes	Yes, for the mega project, the cost was relatively very small compared to the overall project cost.	No answer was given	Yes	No answer was given	No answer was given	Yes	We had a well-equipped company with all the needs that assist the departments to making decisions	Yes
Q42	**Did your company utilize any economic evaluation techniques as part of the decision process?**														
	Yes	No	No answer was given	No answer was given	No answer was given	Risk evaluation workshop and risk registry	Cost estimation report	Unfortunately, No	Risk registry	Cost estimation report	No answer was given	Cost estimation report	Yes	Yes	Yes
Q43	**How did you rate the flexibility in contractual provisions?**														
	It was not flexible due to the different risks that surrounding the projects -serious trouble with the project clauses and contract type.	Flexibility provisions specify a framework for how to renegotiate contracts but it was hard to achieve and it takes a long time.	No answer was given	No answer was given	No answer was given	In order to avoid unnecessary rework Contract strategy must be considered carefully.	Moderated	No flexibility and the contract words lack of its natural and ordinary meaning.	No answer was given	No answer was given	It was not that good	It needs to be considered in the future projects.	No response was given	Contract flexibility was largely unrealized.	It was not easy to achieve.
Q44	**How did your organization make decisions on building a new project?**														
	We had received the instructions from the higher management and then we follow up the normal PM procedures	We had used traditional PM & moving toward stage-gate process to achieve the required objective	No answer was given	No answer was given	No answer was given	No answer was given	We receive the information from the board member then we start the execution	We had used stage-gate oriented process with the leading companies	No response was given	No response was given	After board member approval we follow up the project management process	The board member are the authorized entity to decide the new projects.	No response was given	Board members and higher authorities make the decisions and in our turn we pass them on to related subsidiaries after we have studied them.	No response was given
Q45	**What was the normal procedure for contract awards in your firm with regards to existing construction project?**														
	Experience and low prices	Low price	No answer was given	No answer was given	No answer was given	No answer was given	Low prices and experience	Lowest price and technical experience	No answer was given	Lowest price	Lowest bidder	Low cost	Low price	Technically successful bidder and lowest price.	Good experience with Lowest price
Q46	**What were the main factors (criteria) that play a major role in awarding a contract for a new construction project?**														
	Work experience, knowledge and low price	Technical & previous experience in the same field	No answer was given	No answer was given	No answer was given	No answer was given	Experience and knowledge	Ability of contractors in terms of resources and previous experience.	No answer was given	Experience	Experience in local market, price and reputation	Technology, experience and contract price.	Reputation and work experience	Contractor work experience and other factors	Many factors such as market knowledge, work experience, price.
Q47	**What were the main factors (criteria) that play a major role in awarding of a contract for maintenance of an existing construction project?**														
	Years' of experience and resume	Technical experience	Work experience	Experience	Work experience	Market knowledge and technical experience	Experience and knowledge	Proven prior experience in the same field	No answer was given	Experience	Experience in local market, price and reputation	Technology, experience and contract price.	Experience and knowledge	Previous experience	Experience in the same field.

Table 4.25: Interviewee question and response from Q48 to Q55

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q48	**Was the current contract award mechanism in your company effective?**														
	For some projects yes and sometimes no.	Variant from project to another	No it was not that effective	I don't think so	No	No answer was given	Yes	Not really, because the cycle takes much longer than it should take, causing major schedule delays.	No answer was given	No	No	No	No answer was given	Yes it was	I can say yes, it is based on our resources
Q49	**How can the contractor inputs be included in the design?**														
	The contractor did everything including the design and construction	Contractors handles everything since most of the project contracts were either EPCM or EPC	The contractors did everything from design to project startup.	Design and construction	Technology , design and construction	Everything	The contractor and consulting companies had handled everything	Construction team input & experience did not taken into consideration during the design phase.	The designer did the project design	The project design had done by a leading design firm and reviewed by consulting firm and some of the internal team	Usually the technology provider nominates the designer and the contractor as well.	The selected design company did the design under our supervision .	No answer was given	Their feedback & experience were needed to be considered immediately after signing the contract	The projects either EPC or EPCM
Q50	**How did you evaluate the traditional procurement system (Design-Bid-Build)?**														
	It needs a re-evaluation	Not effective	Needs to reconsidered	No answer was given	No answer was given	No answer was given	Good	Interests and relationships affect the decision-making in this kind of procurement system.	No answer was given	Not effective	Not effective	It needs for a reassessment	No answer was given	Applicable everywhere .	Not bad
Q51	**How can any conflict of interests among project stakeholders be solved?**														
	Through discussion and meetings	Meetings	Meetings and open discussion	Meeting but It was wasting of time	No answer was given	No answer was given	Negotiation and talk	Through mutual resolution and alignment of project targets and goals in the early stages.	Meeting, discussion & commitment	No answer was given	Effective communication and meetings	Meetings and taking into account the interests of all parties.	meetings	communication	Discussion and meetings
Q52	**How did you assess the risk in your projects?**														
	Throughout the cost estimation reports	Workshops, meetings and risk registry	Schedule	According to the planned schedule	No answer was given	Risk registry	Through cost estimation reports	Through project review, facilitated meetings and robust risk register.	Risk registry	Cost estimation	Cost estimation and risk registry	Cost estimation	Risk registry	Early warning signs appear for us when we have up and down risk trends.	Cost estimation
Q53	**What kind of procurement systems tools did you use? How?**														
	Lowest price and our own specific criteria	We are an operation company and don't use such tools.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Lowest price during early stages & "Matman" was a Fluor system for tracking procurement during construction phase	No answer was given	Traditional tool	Traditional procurement evaluation and list	Design-bid-built	No answer was given	You can ask the finance department	It is a contractor responsibility to follow up procurement during the construction phase
Q54	**What were the benefits and drawbacks of implementing technology within the current procurement system? How can it be improved?**														
	Not sure about it but seems effective	No tools	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	"Benefits" were that all of the information is available at the press of a button. "Drawbacks" were data require to be maintained regularly, otherwise the tool will not be effective.	No answer was given	. Not effective	It needs for improvement	It need for reassessment	No response was given	No response was given	No response was given
Q55	**What type of contracts was used for the megaproject?**														
	Usually either EPC or EPCM	-EPC or EPCM. -Most of our project had used EPC	-EPC or EPCM. -EPCM needs a large project team, not effective for our projects, caused many change orders	-EPC or EPCM. -EPCM was not effective locally	-EPCM or EPC -EPC, the full risk lays on the contractor -EPCM responsible about the design not the time & schedule	No answer was given	EPCM and EPC	Hybrid EPC/EPCM reimbursement & different kind of contracts for the small jobs	EPCM and EPC	Two EPCM, to EPC and one EPC lump sum turnkey.	EPC and EPCM	EPC and EPCM	No response was given	No response was given	There are many contracts and each project has specific type of contract. in the latest projects the type were either EPCM or EPC

Table 4.26: Interviewee question and response from Q56 to Q60

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q56	**What was the normal procedure for the contract award with regards to a new construction project?**														
	Low bidder and price	Design-Bid-Award	Lowest price	No answer was given	No answer was given	No answer was given	Experience and low price.	-Lowest price however it was not effective due to the conflict of interests and relationships that had affected the final decision-making	Now answer was given	-Design – bid- built -Lowes price	Lowest price.	The project owner had imposed contract conditions during the contractor's invitation to bid such as squeezing contract time, budget, schedule, & unrealistic construction and delivery time of suppliers.	Low price	Low bidder price	Lowest price
Q57	**How important did you rate time requirement?**														
	It absolutely was so important	It was very important for schedule and execution of the project.	Extremely important	Very important	Extremely important	Too important	Very important	Extremely important for megaproject but delay is scheduled for megaproject.	Extremely important	Very important	Adhere to Schedule is extremely important	It should be schedule-wise and allowance must schedule for construction phase	Very important	it is important for all stakeholders and shareholders	Very important
Q58	**Could you evaluate type of accuracy and reliability of cost estimation?**														
	No answer was given	-Accurate & reliable cost estimation for mine and mine equipment to construct the project. -Accurate resources, budget & expertise to make decision	Higher management financial report during the business study in the conception phase was not accurate.	No answer was given	Delay of project design packages submission by the designer had caused increasing in cost estimation. - the project cost estimation could increase at any stage of project lifecycle	No answer was given	Information of cost estimation had obtained from the contractors at the construction phase and from the market evaluation at the early stages.	Cost estimation accuracy was the main tool to track the project specifically during the construction phase when many contractors involved in the construction activities.	No answer was given	-Market and projects comparison. -the main contractor was responsible about the cost estimation report. - Location, site condition, contract strategy & energy prices had affected on cost estimation.	-Very reliable and accurate if information of feedstock was accurate at the early project stages.	-Cost estimation had depended on the ore deposit accuracy at the early stage of the project. We had got the project cost estimation from estimating previous equipment and project	the project cost estimation had relied on the ore deposit calculation	-Profit & cost estimation were the most important thing -Directors had needed an accurate info to make decision, measure the gross margin, making optimal choices & valuing the assets based on it.	No answer was given
Q59	**Could you evaluate the type of cost estimation technique used?**														
	No answer was given	It was effective & was one of the main contractor responsibilities	Not effective	No answer was given	No answer was given	No answer was given	A monthly cost estimation was one of the most important parameters to measure the progress of megaproject at the construction phase.	Previous project cost estimation report for items & technology and accurate cost estimation for the ore had consumed the time.	No answer was given	CEO wants to see cost estimation report every six months before the construction phase & fortnightly report during the construction activities. -The project contractors spending forecast were the main source of information for the cost estimation	It was an effective traditional way but there were no alternative.	The traditional Cost estimation evaluation had consumed the time but was effective.	No answer was given	Using accurate cost estimation had helped to see project details, manage project, assigning resources & build schedule.	No answer was given
Q60	**Could you evaluate the quality assessment system?**														
	High quality of projects was our first priority	We were applying the international quality assessment & standards to ensure the best results.	No compromise with quality for mega-projects.	Extremely important	High priority	Very important	Time, quality and cost were so important for any project	It had started before the lifecycle of the project at the assessment of ore quality then we had moved to the quality assessment of the contractors, designers, manpower, suppliers & vendors	Mega-project means high quality project.	Extremely important	No trade-off for quality	Extremely important	Extremely important for high cost mega-projects	-We were working according to the international quality standards. -To minimize project time & keep on the quality without trade-off, we need: -Good vendors & procedures -Prequalification for vendors -Good suppliers procedures	Mega-project needs high quality product. Everything had been followed the quality standards

Table 4.27: Interviewee question and response from Q61 to Q66

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q61	**Could you evaluate availability and supplies of resources?**														
	Gold product project is driven by market.	It is extremely important to have the feedstock and financial support and without them we cannot do anything	Shortage of labor and contractors due to market booming.	No answer was given	The regional market boom had caused a project logistics problems, shortage of qualified manpower and contractors.	Lack of contractor knowledge of local market had caused project delay.	No answer was given	Mega-project had contained plants, roads, buildings, train, sea port, electric energy was in need to massive resources in field of technology, human, ore, finance from the beginning of concept phase	Mega-project had started from scratch with no roads, electricity, and water and so on.	The project had located in a remote area with no utilities.	No answer was given	No answer was given	Without it we can't work in every field	We are a mining company and listed in the stock exchange market, we had the natural resources and the support of the shareholders. We are working now on building up our name and brand.	Extremely important for any project and contractor.
Q62	**Could you evaluate the government regulation?**														
	Obtaining project licenses had took time	-It hinder the progress of the project execution. -We had faced difficulties especially in obtaining licenses & with labor laws.	The government had caused a project delay.	Lack of cooperation to issue the permit	We had project permit problems	No answer was given	No answer was given	-Problem with issuing the licenses Interface -Problems with 4 or 5 authorities around the project location, -In the construction phase government change the labor law	-We had faced a difficulties to issue project permits. -there were conflicts between the project and five external authorities -there were a conflict between the local people & project	No answer was given	Procedures and regulations had consumed the project time	No answer was given	Very important	Extremely important to implement projects	Highly important
Q63	**Could you evaluate political situation?**														
	Political stability extremely important for stakeholders.	It was very important since we did not have neither technology nor expertise.	No answer was given	No answer was given	No answer was given	No answer was given	important	It was extremely important for any new industry & especially for our mega-project.	It was extremely important since we had a lack of technology and expertise.	important	important	important	Political stability is an important issue for the government, company, contractors and expertise.	Economic and political stability of any country is a major catalyst for international companies, investors & expertise.	Very important for contract price and kind of contract
Q64	**Could you evaluate the number of competitor on the market?**														
	No local competitors	We did not have local competitors	No local competitors	No local competitors	No local competitors	No local competitors	No local competitors, new project and product.	Aluminum was a new industry in this country.	There was no competitor	New integrated aluminum project. -Market boom had led to increase the project contracts price.	New and a unique project	New project	No competitors	We had an international competitors for all of our products and we work with them to support our product & to find a foothold in the global market.	We did not have local competitors.
Q65	**Could you evaluate culture impact?**														
	A part of our project was with Asian companies and it was a new and hard experience.	-No effective management plan in remote area. -The communication language was English and the international technical & non-technical standards -Asian companies did not used with the international standards.	No answer was given	Language difficulties with Asian companies	Asian companies was imposed on us due to the market booming and other circumstances.	A lack of communication plan within the departments and with the Asian contractors.	No answer was given	-There were positive & negative impacts on the project progression since there were contractors from all over the world --Most of the workers were expertise. -The impact was positive except in cooperation at construction phase.	No answer was given	No answer was given	No answer was given	No answer was given	It had either positive or negative impact	Culture diversity is important element for our company since we had different products and projects, & we are in need to expertise in different fields.	It was very important for the contract and we had to facilitate the contractors job especially during the construction phase
Q66	**Could you rate weather condition?**														
	No answer was given	It was extremely important before doing the design phase.	No answer was given	No answer was given	No answer was given	In risk management everything is important	No answer was given	Weather had moderate impact on the progress of the project during construction phase & it was important for design phases	Important	No answer was given	No answer was given	No answer was given	No answer was given	It was not an issue in the modern era and with the development of technology.	It is important for the contract.

Table 4.28: Interviewee question and response from Q67 to Q73

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q67	Could you evaluate the project location?														
	We had faced difficulties with the water, electricity and mobilization of the contractors during construction phase	We had faced serious difficulties with the location such as utilities, logistics & mobilization of manpower to the location.	No answer was given	No answer was given	Important especially for logistics.	-Utilities -Logistics to remote area and the location were important.	No answer was given	The project had a lack of all the necessities of life at the concept phase. The mine located far away from the plants location & sea port. We had faced risks in everything.	-Interface difficulties with five gov. authorities around the project location. -The project had commun. Hurdles with the herders.	Lack of utilities and necessities	Extremely important	Very important	Extremely important for logistics, construction & product	It was extremely important to have a project next to the facilities & resources, but the ore located in the remote areas.	Very important for the contract prices & labor cost
Q68	Could you evaluate the project duration?														
	Some project had delayed due to different reasons such contractors	Contract time was not realistic. We had problem with contract biding time, design, & construction.	No realistic & inadequate	We had a planning problem	Design bidding plan, & evaluation had consumed the project time.	No answer was given	It must be reasonable	There were a lack of plan of managing project delays.	Project had delayed	It had took long time.	Important	Very important	Very important for the owner, product & contractor as well.	Variant from project to another & important for shareholders	Extremely important for negotiation contract & price
Q69	Who was your project team leader?														
	Technology had provided by mining company, construction by intel's company.	Foreigner contractors for: Data collection, designer & construction	intel's companies	Different intel's contractors	A leading company for design, another for construction	For mega-projects, intel's companies	Leading company in the mining field, construction, design and management	Five main international contractors for each project & one of them was the project team leader.	Leading companies	A leading PM team. -Five Leading companies had built mega-project with the help of contractors & sub - contractors.	Usually the technology provider	Leading companies	International companies in the mining, construction and design. -Expertise had attracted to mega-projects	External to the team but internal to the owner.	Leading companies in the mining or in project management field.
Q70	Who, generally, was responsible for carrying out the project during conceptual/initiation and planning phases?														
	Consulting firms, different designers and contractors	An international contractors	Technology providers and contractors	Shareholders ,designers and consultants	A leading company	An intel's companies	Leading firms and consultants	An external project management team (outside of the organization)	External project teams	Different external teams	Technology providers	A leading company	Intel's company	A leading firm	Usually technology providers in mining field or PM company
Q71	Who, generally, was responsible for conducting design changes in the initiation phase and prefeasibility phase?														
	Higher management, designer, consultant & our project team	Technology provider, design company, project team & consultant	Designer, consultant and our project team	Project team in mining field including external consultants and the designer	Designer, value management consultant and internal project team	Intel's' Companies.	The designer and consultant teams.	The internal project management team and main contractor	Designer & internal project management team	Most of the internal project management team did not participated in the design review workshops at early stages	Technology provider & main contractors	The main contractor under some internal supervision .	Internal & external design teams	Project management company and design company	Designer, consultants and leading project management firm.
Q72	What size was your project management team?														
	We had geologists, mine and execution teams and operators under training	Small project management team	A new team and a few in numbers.	Small team No.	Small size	We had a small team	Small at the beginning of the project.	80 to 120 members at the construction phase	No answer was given	Small at the early stages	Small	Our role is supervision and following up the project outcome.	Different sizes for each project	We have many project with different sizes in each subsidiary	We had signed PM agreement with leading companies to manage the projects
Q73	Could you evaluate the number of team members?														
	We had shortage of project management team	The main contractor had handled the project activities from concept to execution phase under our supervision.	A few in numbers.	Small team number	Small-sized	We had a small team	I spent 65% of me team to find expertise for every department	It was very important to have expertise to deal with the companies, contractors & different authorities.	We had a lack of internal technical expertise	The project team number had impacted negatively on the effectiveness of project and process	Very important	Project management teams whither technical & non-technical are important	Extremely important for projects during different phases	It was very important for any business to have expertise in every department	Expertise & their existence could effect on the contract price.

Table 4.29: Interviewee question and response from Q74 to Q78

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q74	**Did you employ an external team to carry out the project prefeasibility study and planning? If so, why?**														
	The whole projects had handled by contractors but under of our supervision and management.	Yes, it was conducted by an external team due to the lack of an expertise in ore calculation, design, value management & supervision.	Yes, it had done by different contractors in different fields.	The project had a lack of professional technical team.	Yes from A to Z	No answer was given	Yes due to the lack of expertise and knowledge in the mining field	Our project was a new, complex & unique. We had neither the technology nor the experience to run such a mega-project.	Yes	Yes since it is a large project with a new technology	Yes since we had limited manpower	Yes due to the lack of internal project management team	Yes because we did not have technical teams	As a new company we had need to work closely with expertise in every field both internally & externally especially during prefeasibility & planning stages.	Yes since we had a lack of technical teams
Q75	**How did you evaluate the importance of the teamwork?**														
	-It is very important. We had hired expertise in different departments. -The projects had managed by two VPs' in construction phase.	We had been still in the process of establishing a professional team.	Extremely important	Very important	Too important	Highly important	It was crucial for every department and phase.	We had a massive mega-projects & seriously we had a lack of team work.	It was very important especially at the construction phase	Every project needs the teamwork but in our project it was not effective enough.	Very important during the whole project stages.	Honesty and integrity of team members and top management are important to implementing the mega-projects.	Extremely important	It obviously was very important for our medium-sized company	Very important
Q76	**How was the design team briefed?**														
	Projects design usually had done by a leading firm in the design	.We did not have a design team but the project had design problems.	External design contractor and consultant had done the project design	Not effective and causes design problem	Project design was outsourcing and some of project teams did not participate in the design phase.	-We had faced difficulties with the design -Operation and maintenance teams did not participated in the design phase.	It was a leading designing firm	Lack of design team that be in the loop of information with construction & operation from the early stage of the project.	Main contractor	.Designer and consulting companies did the designed and reviewed with some of the internal team	It was the technology provider	Usually the technology provider nominates the designer and the contractor for the project owner	Weak	Maintenance team had not considered the inclusion of the design team	We had signed contracts with design companies and consultants to follow up the design phases.
Q77	**What was the appropriate team to conduct design change? Why?**														
	No answer was given	Technical teams, all contractors, construction, operation & maintenance.	No answer was given	All technical departments and engineering	All stakeholders	Project team, operators, maintenance & production teams	All departments	All parties (Engineering, construction management & operations)	Key people from every department	Stakeholders	All technical departments	Stakeholders	Stakeholders	Technical teams in every field	All of engineering departments
Q78	**How did you evaluate the cultural and operating factors among the various regions?**														
	Generally positive	We had dealt with different countries & cultures. The contract and international technical standards were the sole communication language.	It was good	It was not that bad	It was good in general	It was quite good	No answer was given	Cultural Factors had their own impact on the effectiveness of project & process due to the diversity of work, firms, contracts & projects teams	No answer was given	No answer was given	No answer was given	No answer was given	No response was given	There are many factors could affect the operating plan such as project start up delays, change of business plan and future resources.	No response was given

Table 4.30: Interviewee question and response from Q79 to Q84

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6	Interviewee 7	Interviewee 8	Interviewee 9	Interviewee 10	Interviewee 11	Interviewee 12	Interviewee 13	Interviewee 14	Interviewee 15
Q79	What methods did you use to carry out the project during the conceptual and prefeasibility phases?														
	Open discussion, meetings and technical workshop	Meetings & workshops	No answer was given	No answer was given	No answer was given	No answer was given	Meetings and workshops	Workshops varied according to the needs of the project	Meetings	Workshops	Meetings and workshops	Meeting, PowerPoint slides, boards and open discussions	Meeting and workshops	Workshops	Meetings
Q80	What percentage of time did you spend on function analysis during the early stages?														
	No answer was given	30%	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	26% to 50%	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Technical team can answer this question	No answer was given
Q81	What did you do for the cases for which you did not use function analysis?														
	No answer was given	With or without analysis we had to a find way out to take the project to the next level during construction phase.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Sometimes external stakeholders & project objectives dictate requirements that have to be met regardless of the analysis.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Technical team can answer this question	No answer was given
Q82	How did you select functions for the project?														
	Previous projects	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Life cycle cost models.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Technical team can answer this question	No answer was given
Q83	Which function analysis techniques did you use?														
	Comparing with previous projects	Numerical analysis and evaluation	Comparison	Comparing items and equipment	No answer was given	No answer was given	No answer was given	Comparative evaluation	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Technical team can answer this question	No answer was given
Q84	Which function analysis technique did you use in the evaluation stage to compare alternatives?														
	Comparing with previous projects	Data evaluation and comparison	Comparison but at the project early stages the project management department had received inaccurate financial model analysis report from the finance department, which was not around +-10	Comparing items and equipment	No answer was given	No answer was given	No answer was given	Evaluation by comparison.	No answer was given	No answer was given	No answer was given	No answer was given	No answer was given	Technical team can answer this question	No answer was given

4.4 Analysis of Responses

This section represents the analysis of the responses given by the interviewees of the gold subsidiary, the aluminum subsidiary and the headquarters.

4.4.1 The definition of mega engineering project in the mining field at the early stage (Questions 3-6)

Six senior directors and managers of planning and executing project management team were asked a series of questions about the Mega-project's development and execution phases.

4.4.1.1 The gold subsidiary responses to a definition of mega-project in mining field at the conception phase

Interviewees from the gold company were asked about the mega-project definition and image at the beginning of the project.

Interviewee 1 stated that the company had 8 mining projects and the cost and the size defined the mega-project. He added that the company and project teams had lacked a theoretical and professional image of megaproject at the conception and prefeasibility phases. Interviewee 3 stated that it was hard to visualize the mega-project processes at the conception and prefeasibility phases. Interviewee 2 defined the megaproject based on the difficulties, technology used and project budget. He added that the meg-project had been difficult to visualize and implement without the support of the technology providers and designer especially at the conception and prefeasibility phases. He stated that the meg-project was driven by technology, experience and expertise in the mining field, and measured by the quantity of the mineral resource and had needed a good project definition. He added that the project had used traditional project management delivery which was the just-in-time project delivery type and parallel workflow models to implement the project.

It seems, therefore, that there had been a lack of knowledge about the mega-project processes at the early stages of the project and until the end of the prefeasibility phase. In addition, the mega-project could not be defined and had not been properly understood. The company had used the traditional project management processes to deliver the project not the stage-gate process. The megaproject uncertainty and ambiguity were high at the early stages. There had been full dependence on the technology provider and project designer to visualize and implement the projects due to the lack of expertise in the mining field from the owner side.

4.4.1.2 Aluminium subsidiary responses to a definition of mega-project in mining field at the conception phase

When the aluminum company interviewees were asked about the mega-project definition and image at the beginning of the project, their responses were considerably different to those of the gold company interviewees.

Both Interviewee 8 and 10 stated the project capital cost was $10.8 billion dollars. Interviewees 7, 8, 11 and 12 stated that the theoretical image of the mega-project was ambiguous at the project early phases due to the lack of expertise and technology. Both interviewees 7 and 8 agreed that the mega-project can be defined by the size of the project and capital cost. Furthermore interviewee 8 added that parties involved and technology can also define the megaproject. Unlike interviewees 7 and 8, interviewees 11 and 12 had defined the megaproject by cost. Both interviewee 7 and 8 stated that the mega-project had been driven by engineering expertise and delivered by using traditional project management process. The project director, interviewee 8, added that the megaproject in the mining field at the early stages had been measured by availability of resources, project scope and monitored weekly to adjust any deviation from baseline. It seems, therefore, that the project image at the early stages was not clear due to the size of the project and lack of expertise. There had been a lack of defining the mega-project and visualizing the project scope, a lack of monitoring and supervising the project activities and also almost total dependency on the main contractor to visualize and manage the project activities during the early stages and implement the project at the construction phase.

4.4.1.3 Headquarter's responses to a definition of mega-project in mining field at the conception phase

Higher management interviewees were asked about the mega-project definition and image at the beginning of the project.

Interviewee 14 stated that the parent company had around 10 projects - some were mega-projects and another were major projects. Both interviewees 13 and 14 stated that a megaproject in the mining field is not always as glorious as people think it is. The interviewees 13 and 14 added that the project cost and size defines the mega-project.

It seems, therefore, that the company found difficulty to define and to visualize megaproject at the early stages of the project lifecycle but agreed that the megaproject could be defined in terms of cost and size.

4.4.2 Traditional project management process and stage-gate process at early phase (Questions 7, 10, 44)

Six senior directors and managers of planning and executing project management team were asked a series of questions about the mega-projects development and execution phases.

4.4.2.1 Gold subsidiary responses to traditional PM process & stage-gate process

The gold company Interviewees were firstly asked about what type of project process at the mega-project concept and prefeasibility phase had been used by the company.

Interviewee 1 stated that the gold firm had used the traditional project management processes for some time to implement company projects. However the stage-gate process which had been introduced to the company recently to implement the design phase of projects with the design contractor used the same stage-gate process as a design evaluation tool. Interviewee 1 added that the stage-gate processes had been used as tools to evaluate the three stages of the Front-End Engineering Design (FEED) for basic design at the prefeasibility phase and detailed design at the feasibility phase but had not been implemented for the rest of the project processes. Moreover there had been difficulties at the early phases with the design evaluation and the selection of contractors. Interviewee 4 added that the stage-gate process workshop with the leading contractor had covered the three stages of design evaluation, as well as economic parameters such as IRR, ROI & NPV, value engineering, HAZOPS and operability study. Four of the interviewees (2, 3, 4, and 5) stated that the internal project management team had lacked technical experience in the mining field, and lack of time to study and evaluate the technical items that had been given by the company to the project and consultant teams during the design phases. Both Interviewees 1 and 2 stated that the higher management had delayed the project stage-gate process approval. It seems that the company had completely depended on the external technical consultant and the main design contractor during the design phase process despite the length of the design review period, design mistakes and differing views. Three interviewees, 4, 5 and 6, agreed that project stakeholders such as operation and maintenance had not been involved in the stage-gate process workshops and evaluation of prefeasibility and feasibility phases of the design stages.

Both interviewee 1 and interviewee 2, who came from a mining engineering back ground and experience, added that the theoretical process of the stage-gate process needed modification in order to suit the mining sector and specifically their company. Interviewee 2 added that the stage-gate process was not well identified.

It seems, therefore, that there was disagreement as to the application of stage-gate process or chart among the project new comers who had had experience of petrochemical and oil and gas projects.

Interviewees 1, 2 and 3 stated that the final approval from the board members for each stage of the design phases had taken a long time, and even consumed time during the analysis and evaluation stages. Interviewee 3, who had broad experience in the stage-gate process, added that the stage-gate approval process from the board members at the end of each design stage or what is called 'gatekeeper' evaluation stage was the main cause for design changes at the basic and detailed design phases.

Figure 4.1 shows the problems arising from the replacement of the traditional project management process with the stage-gate process especially in the design phases. The percentages were calculated by giving each interviewee or a voter a unit weight equal to 0.166. Thus, two voters had got a unit weight equal to 0.333, three voters had got 0.500 and four voters have got 0.666.

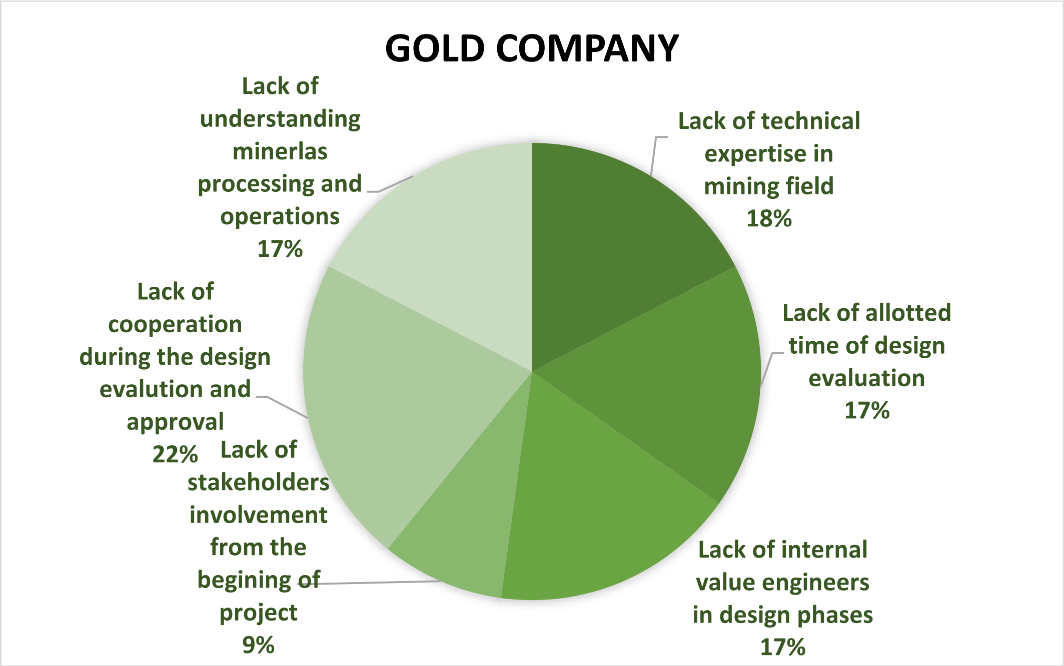


Figure 4.1: Gold company difficulties during design phases and stage-gate process

The problems included lack of technical expertise in the mining field, lack of allotted time for design evaluation, lack of internal value engineers for the design phases, lack of cooperation among the stakeholders during the design evaluation and approval, lack of defining and understanding stage-gate deliverables and lack of knowledge of mineral processing and operation, lack of stakeholders' involvement from the beginning of the project as well as lack of maintenance, operation and production team involvement in the project process from the prefeasibility stage until the execution phase, specifically at the design phases; in addition there was a lack of cooperation between the project internal team and project main contractor from the beginning until the execution phases.

4.4.2.2 Aluminium subsidiary responses to traditional PM process and stage-gate process

The aluminum company interviewees were also firstly asked what type of project process at the Mega-project concept and prefeasibility phase the company had used. Four Interviewees (7, 8, 11 and 12) stated that the traditional project management process had been the tool used to implement the mega-project during the concept stage. However after signing the management contract, the project management, procurement and construction became the responsibility of the main contractor due to the lack of integrated megaproject management teams for the prefeasibility and feasibility phases. Interviewee 11 and interviewee 12 added that traditional project management was useful and adequate for operation companies that have medium-sized projects, a small project management team and no future project plans.

Interviewee 7, who had had broad experience with petrochemical projects and stage-gate process emphasized the importance of the stage-gate process and the need to link the stage-gate process to the right discipline or department and team.

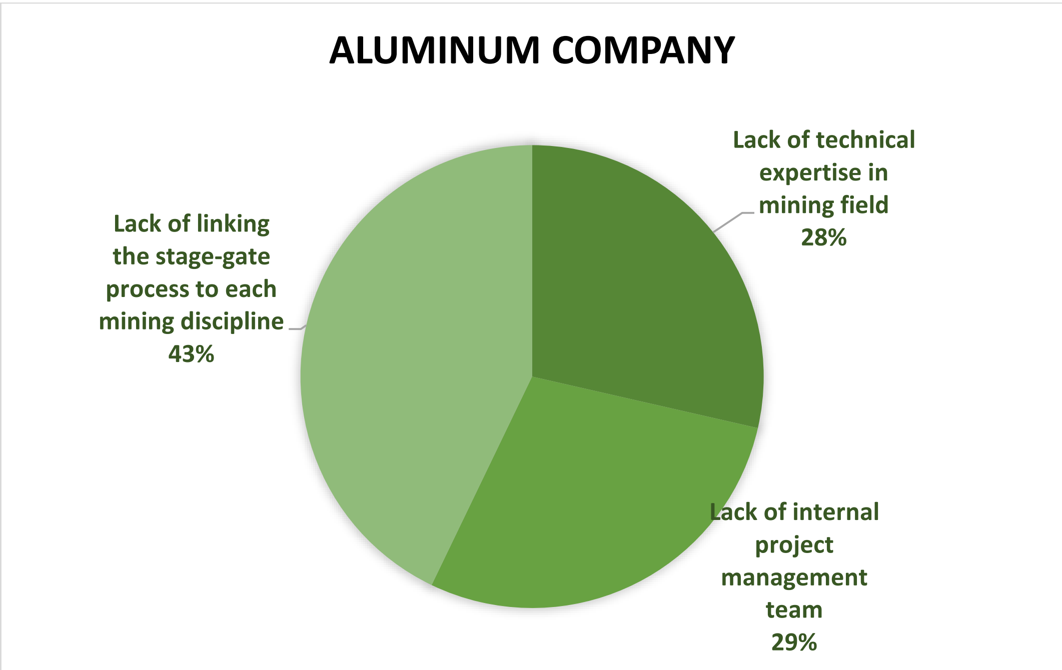


Figure 4.2: Aluminum company difficulties during design phases and stage-gate process.

It seems, therefore, that, as shown in Figure 4.2, there lacked an internal project management team, there was a lack of technical expertise in the mining field, unappropriated linking of the stage-gate process to key stage deliverables and some disciplines, lack of applying and understanding the stage-gate process in the mining field except for the design phase, difficulties implementing the stage-gate process for mineral project and process.

4.4.2.3 Headquarter's (business unit) responses to traditional PM process and stage-gate process

The higher management interviewees at the business unit were firstly asked what type of project process at the mega-project concept and prefeasibility phase the company had used.

Both interviewees 13 and 14, who had had broad work experience in the oil and gas projects, stated that the company had used traditional project management for previous megaprojects at the concept and pre-feasibility phases but the rest of the project processes such as feasibility, execution and start-up phases had been handled by the main project management contractor. Both interviewees added that the company with its subsidiaries had moved toward an integrated stage-gate process for the benefit of the future projects. In response to a question about how did your organization make decisions on building a new project, Interviewee 13 stated that board members and higher authorities had made the decisions which then had been passed on to the related subsidiaries after having been studied.

It seems, therefore, that, as shown in Figure 4.3, the company suffered from a lack of in-house technical and non-technical experts in the field of mining, lack of mining project engineers and ineffectiveness of traditional project management processes in the mining mega-projects.

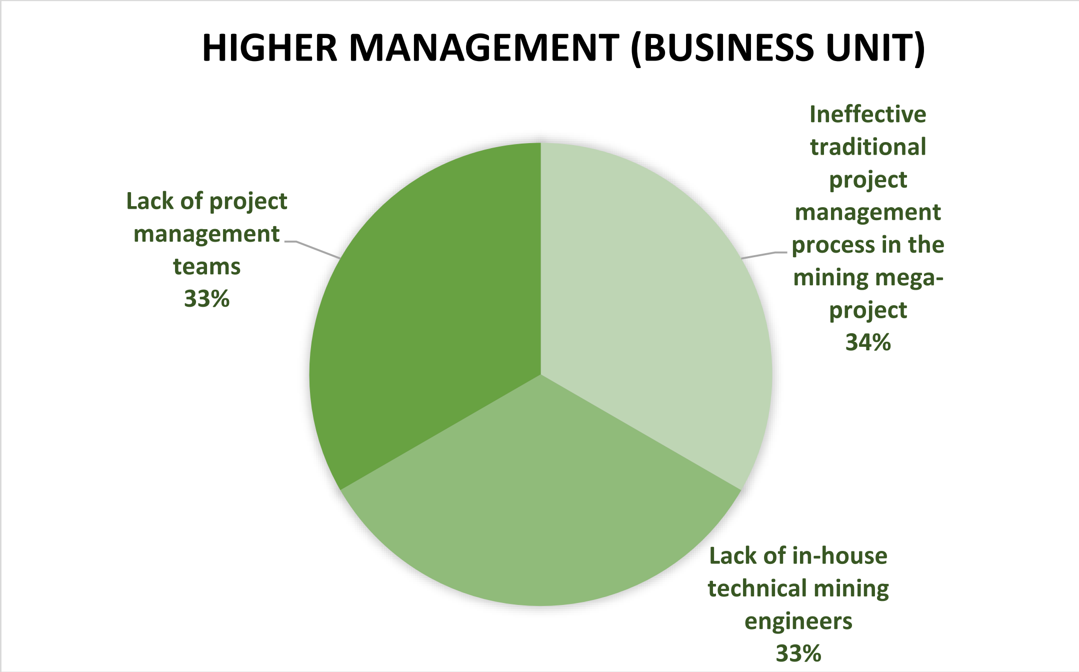


Figure 4.3: Higher management views of stage-gate process and traditional project management

In conclusion, a comparison of the results of Figures 4.1, 4.2, 4.3 show that the company faced obstacles with the stage-gate process for the mining field: shortage of technical expertise in the mining field, a lack of internal project management team for the mining field, ineffectiveness of traditional project management processes in the mining mega-projects, unappropriated linking of the stage-gate process to key stage deliverables and some disciplines, absence of value management engineers and mining engineers, delay in design assessment approval decisions, a lack of cooperation among all of the stakeholders, a lack of defining and understanding stage-gate deliverables for mining projects, a lack of cooperation during the design evaluation and approval, a lack of allotted time for design evaluation and finally a lack of cooperation and communication between contractors and the owner project team.

4.4.3 The mega-projects scope of work and scope creep (Questions 12–15–24, 27)

4.4.3.1 Gold subsidiary responses to project scope creep

The Interviewees of the gold company were asked questions with regard to scope and scope creep from the beginning of the project lifecycle.

Interviewee 1, an executive, stated that they had done scope changes or change orders once or twice a month for 22 months of the project. Interviewee 2 stated that scope creep was considered as a major ongoing cost for the megaproject. Both Interviewees 1 and 2 stated that inaccurate information of ore data (quantity and quality) at the conception phase caused a scope creep at the design phases. Interviewee 1 added that the basic design at the prefeasibility phase and detailed design at the feasibility phase had had serious problems due to inaccurate information concerning raw materials or ore deposit at the initiation or concept phase. Both interviewees 4 and 5, who were part of the project control and execution team, agreed that the project scope of work had not been defined precisely at the concept and prefeasibility phases. Interviewee 3 stated that the major cause of scope creep or scope change had been the owner. He added that the contract awarding mechanism, based on low price as well as the different thoughts of the project team, had caused scope of work creep and had led to changes and delays in the project execution. One of the project control representatives, Interviewee 6, stated that the contractor or design consultant bore a large part of the responsibility for scope creep at the prefeasibility phase due to a lack of knowledge of the local market and due to implementing the basic design in offshore offices without following up with the internal project team according to the contract awarding mechanism agreement. Figure 4.4 shows the reasons for scope creep.

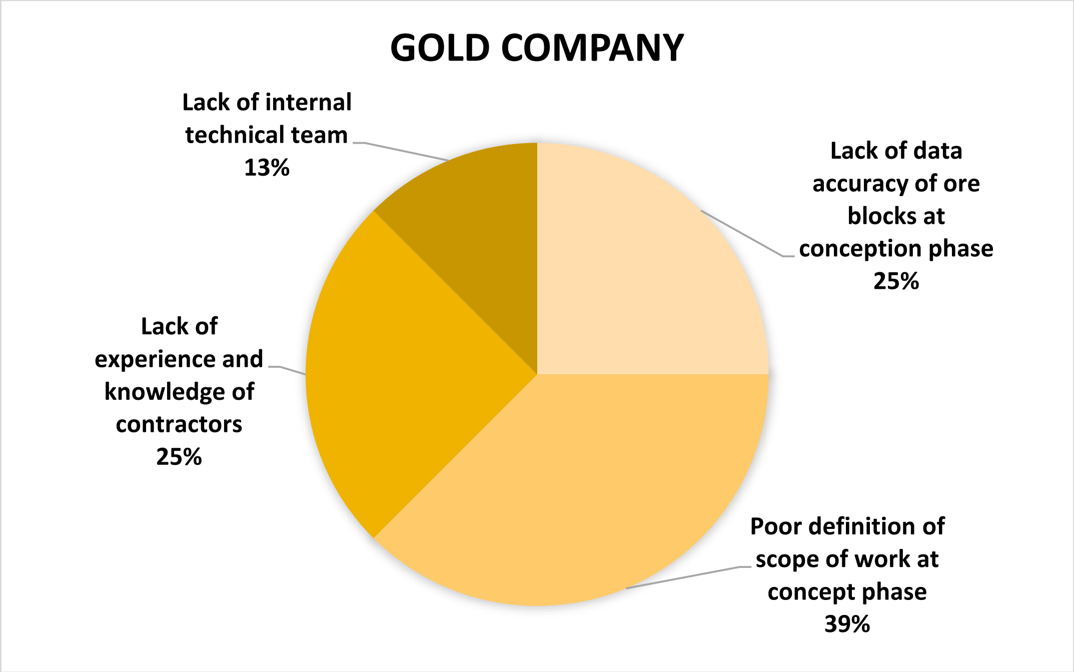


Figure 4.4: Reasons of scope creep in the gold mining company projects

It is clear that, as shown in Figure 4.4, the scope creep in mining gold company projects had occurred for different reasons: firstly an inaccurate measurement of raw material; secondly, lack of internal technical team; thirdly inaccurate design information; fourthly inappropriate contract awarding strategy and negotiation of contract clauses especially for the location of the design and design teams; fifthly the inexperience of contractors and subcontractors in the local market and unproven previous work experience in the fields of engineering, procurement and construction (EPC contract); sixthly poorly-defined scope and scope of work change by the owner had taken place at various stages of the project lifecycle. Finally the responses showed that project planning and inter-disciplinary communication among the stakeholders had been ineffective.

4.4.3.2 Aluminium subsidiary responses to project scope creep

When the Interviewees of the aluminum company were asked questions with regard to scope and scope creep from the beginning of the project lifecycle, their responses were considerably different to those of the gold company interviewees.

All interviewees agreed that there were ongoing change orders during the project lifecycle. Interviewee 8, the project director, stated that the company had changed the scope of work of the megaproject more than 5 times during the construction phase and many times during the basic and detailed engineering stages. Interviewees of the aluminum company listed 17 reasons which had caused the project scoop creep from the concept phase until the start-up of the project. Six of the interviewees agreed on 6 reasons which had caused scope creep. The six interviewees (7, 8, 9, 10, 11 and 12), three of them representing the project execution team and two of them being the main project partners, agreed that the main design-build contractor had complicated the project progress during the prefeasibility and feasibility phases. They added that lack of local mining contractors, mining services and mining vendors had contributed as a cause of project change orders and changed scope of work. Another five interviewees (8, 9, 10, 11 and 12) agreed that the scope creep had occurred due to lack of project supervision. The latter occurred due to lacking an internal project management team and internal technical team. A further two interviewees (11 and 12), the project partners, stated that the project scope creep had occurred due to different reasons such as contract agreement with the owner, contract agreement with the technology provider and amended project scope by the owner at different times of the project's life. Interviewee 11, a main partner and a representative at the higher management level, and another interviewee 10, the representative of the owner in the department of finance, stated that the transformation of megaproject from construction to operation had caused the scope creep and cost overrun due to several reasons one of which was a lack of high-tech expertise in mining operations especially expertise in start-up of high-tech mining equipment. This could have been due to the limited number of experts who had had expertise in modern mining operations; the new trainees also could not manage the integration phase from end-stage project to production. Both interviewees (10 and 11) added that inaccurate raw material information and inaccurate project information at the concept and construction phases had caused scope creep and change. Interviewee 10, the finance Manager, added that inaccurate cost estimation information from the main contractor during the construction phase had caused the scope creep. Both interviewees (10 and 11) stated that the unstable supply of utilities such as gas, electricity and water at any stage of the project lifecycle had been another cause of change of scope of work.

In addition the interviewees listed 9 management actions that had caused the scope creep. The project partner, interviewee 12, who represented the planning department, mentioned that the poor project planning and the delay of board members' approval at each stage of the stage-gate process had caused project delay. In his turn, the project director for the execution phase, Interviewee 9, stated that scope creep had occurred for different reasons: lack of government cooperation with the company during the conception and construction phases regarding land conflicts around the project location and issuing of licenses. Interviewee 10 stated that the owner had caused the project scope creep many times from the beginning of the project and at the construction phase in order to increase the project capacity. Interviewee 11 stated that the delayed bank loan caused scope creep due to inaccurate ore block estimation and tryout of the newest unproven technologies had caused project delay at the construction phase.

It seems therefore that many change orders or scope creep had occurred during the project lifecycle (see Figure 4.5). The differing reasons provided could have been due to the fact that one interviewee (10) was in the finance area, two interviewees (11, 12) were project partners, two interviewees (8, 9) were project directors at the construction phase and one interviewee was the head of the company. It is axiomatic that the change scope of work and the scope creep are still major issues in the world of project management.

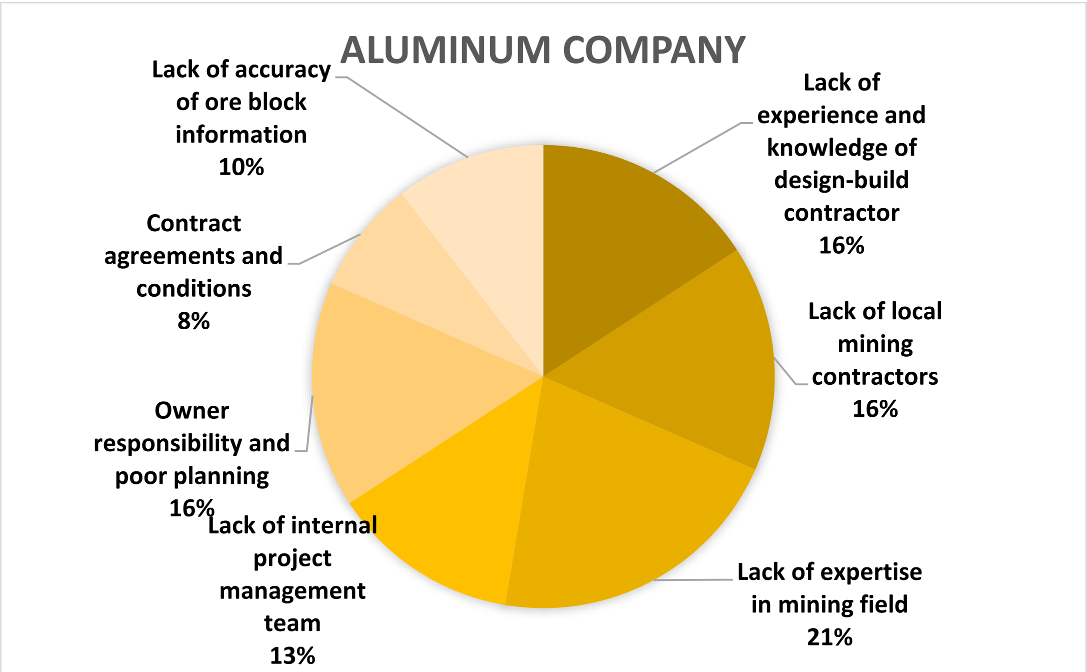


Figure 4.5: Reasons of scope creep in mining aluminum company projects

In conclusion, the project scope creep and project change order in mining aluminum company projects had occurred for different reasons: lack of accuracy of ore block information, lack of experience and knowledge of design contractor at the prefeasibility phase, lack of local mining contractors, lack of expertise in the mining field, lack of internal project management team in the mining field and poor planning at the prefeasibility phase from the owner side and the unplanned extra requirements added to the project at the construction phase.

4.4.3.3 Headquarter's (Business unit) responses to project scope creep

Different responses to those provided by the gold and aluminum company interviewees were provided by the interviewees of the higher management (business unit) at the headquarters when asked about scope and scope creep from the beginning of the mega-project lifecycle.

Interviewees 13 and 14 represented the top-level management at the corporation headquarters; they stated that shortage of contractors and subcontractors in the mining field, poor knowledge of the local market by contractors and a lack of knowledge of modern mining technology by contractor/ supplier/ vender were the main reasons for scope creep and for the project failing to meet business objectives and implementation deadlines. Interviewee 14 added that scope creep had occurred due to poor planning, while interviewee 13 stated that scope creep had occurred due to delay of project loan and imposition of board members' decisions on the company strategy and on an award contractors. The representative of contracting department, interviewee 15, reported that each project is unique and contract agreements vary from project to project, and scope creep may occur as a result of the contract strategy or clauses; however, to avoid such events, he stated that unit price contract strategy could be used in some cases such as unknown project scope of work and unknown modern technology.

Therefore it is clear that mega-project scope changes in the mining corporation projects had occurred due to several reasons; most of the difficulties, it was reported, had occurred because of lack of expertise in the mining field, lack of organization transition process from government to public, poor planning in the concept and prefeasibility phases, non-incomplete contracting agreement and clauses, a lack of the proper contractor /supplier /vendor /fabricator for mining projects and lack of control over subcontractors in the site preparation stage and construction phase.

Figure 4.6 shows that the scope creep causes were: lack of proper project planning, lack of expertise in the mining field, lack of internal project management team, inappropriate intervention of the owner in strategy and contract awards, and finally problems arising from contract management planning strategy, clauses and contractors. These interviewees, of course, were not involved in technical issues due to their position in the hierarchy.

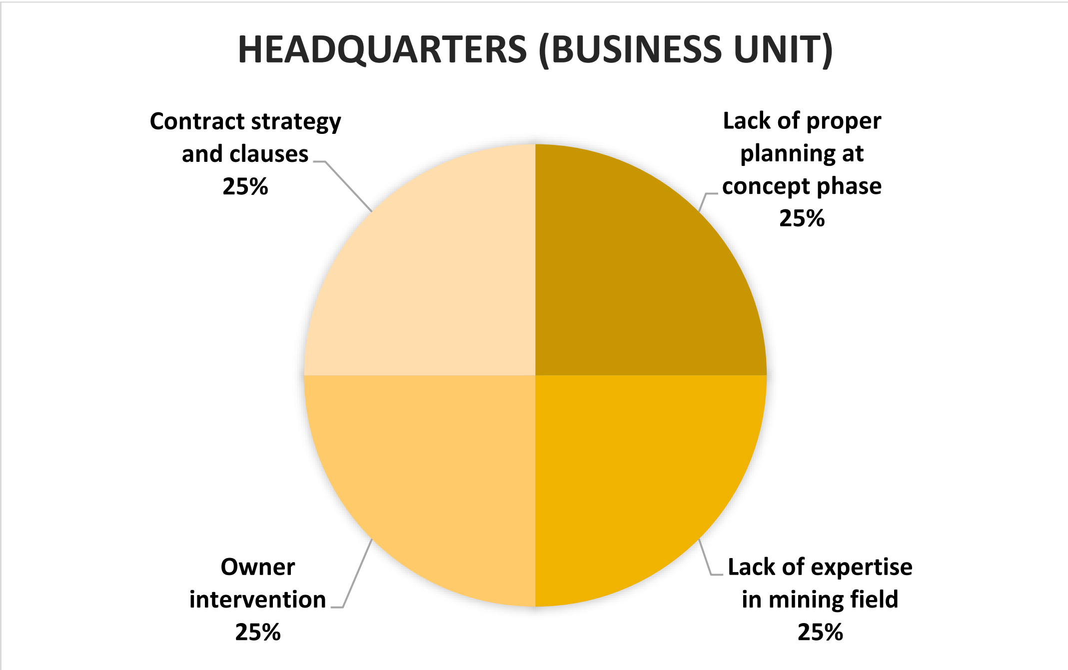


Figure 4.6: Reasons of scope creep from the perspective of higher management at the headquarters

In conclusion, the results shown in Figures 4.4, 4.5, 4.6 show that the company had faced technical and nontechnical hitches with the project scope of work and project change orders caused by: inappropriate contract strategy, contract award mechanism, imposition of unqualified contractors on the company by the owner (the government and higher management) especially the main contractor and some of subcontractors, owner intervention in decision making, lack of data accuracy at the conception phase, lack of mining expertise, lack of internal project management team, lack of mining engineers, poor quality project definition and poor project planning and lack of local mining contractors.

4.4.4 The Contract strategy and award mechanism (Questions 8,10,22,43 to 56)

4.4.4.1 Gold subsidiary responses to contract award mechanism and strategy

Interviewees of the gold company were asked about the reasons for lack of effectiveness of contract award mechanism and strategy for previous megaprojects.

These interviewees stated that most of the project contract strategies applied locally were either EPC/LSTK or EPCM/LSTK type of contract.

The risk management manager, Interviewee 6, stated that a choice of contract strategy is essential and must be considered carefully in order to avoid unnecessary rework during project lifecycle and to prevent the project from not being completed. Interviewee 1, as an executive, stated that there had been serious problems with the project clauses and contract type.

Two members of the project execution team, interviewees 3 and 4, stated that the EPCM type of contract had not been successful locally, while a project developer, interviewee 2, stated that the EPC type of the contract was the usual one used for the implementation of their projects. The representative of the quality control department, interviewee 4, stated that the use of the EPCM type of contract had caused many project change orders. He explained that there had been delays in the execution of the project due to delays related to contractor mobilization to the project location after signing the contract. Interviewee 5 compared? the two main types of project contract strategies and stated that in the EPC contract, the full risk lay on the contractor but the company could not change any order after it had signed the contract, while in the EPCM contract, the contractor was responsible for the project design and if there were a design delivery delay, it could cost the project.

Interviewees 1, 2 and 3 stated that the traditional procurement contract (Design-Bid-Build) based on the lowest bidder or price for billions of dollar mega-projects was an ineffective system and needed to be changed or improved. Figure 4.7 shows the ineffectiveness of contract award mechanism and strategies for the previous projects.

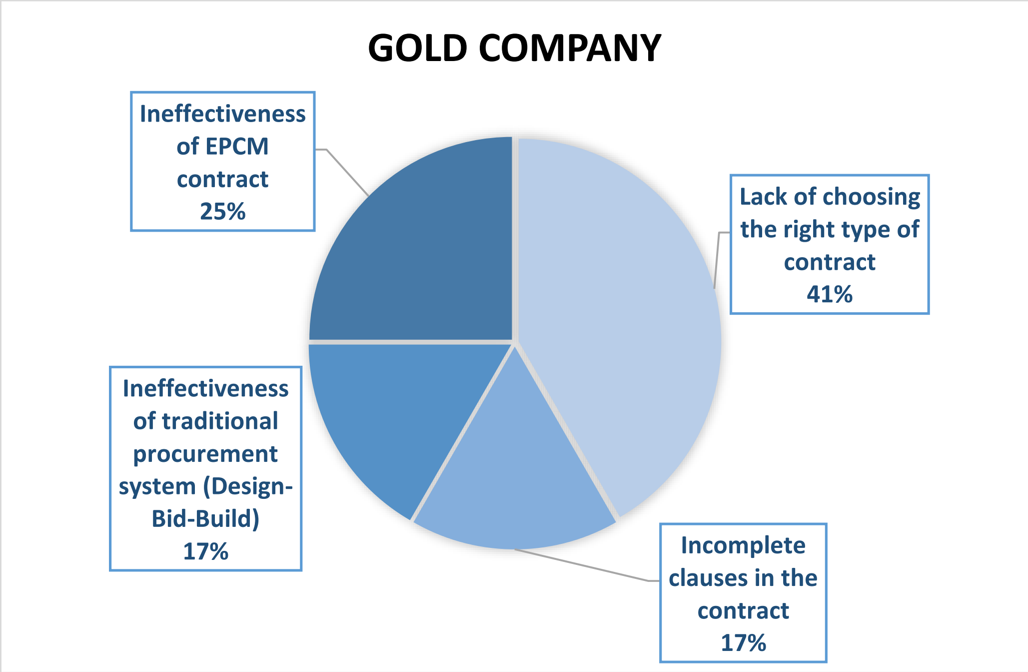


Figure 4.7: The reasons for the ineffectiveness of contract award mechanism and strategy in mining gold company projects

It seems, therefore, that, as shown in Figure 4.7, the effectiveness of the gold company projects had been affected by the contract strategy, contract clauses, and contract process award; moreover, the procurement contract of the traditional procurement system had caused project delays and had impacted on the course, events and scope of the project.

4.4.4.2 Aluminium subsidiary responses to contract award mechanism and strategy

Responses from the interviewees of the aluminum company with regards to the reasons for lack of effectiveness of contract award mechanism and strategy for previous megaprojects provided their perceptions with regards to their own projects on the mega-project.

Interviewee 8 stated that the company had had two EPCM contracts with leading companies, two EPC contracts and one EPC/LSTK contract. He added that the cost of change orders in the EPC/LSTK contract had been higher than the change order costs with the EPCM contract. The project financial manager, interviewee 10, and a project director, interviewee 8, stated that the type of project contract affects project cost estimation but unlike EPC, the EPCM contract had allowed changes during the project lifecycle. For example, it had allowed expansion of a part of the project and addition of new technology during the construction phase.

Interviewee 8 stated that EPC/LSTK contract strategy was preferred for services and small projects. However, the drawback, he stated, of the EPC/LSTK contract was the fixed price and impossibility of changing or adding anything after signing the contract. Interviewee 9, a project director, stated that the project had faced a major risk with the EPC/LSTK contractor who had been declared bankrupt in the middle of the construction phase.

Interviewee 12, project partner and planner, stated that the EPC contract agreement and clauses had not considered some conditions and had affected the project started-up phase specifically at the mechanical completion stage as a result of the exclusion of this part of the contract clauses.

Regarding the traditional procurement contract system, Interviewee 8, project director, stated that the traditional procurement contract system was not effective due to the conflict of interests and relationships that had affected the final decision-making.

Interviewee 12, project partner and planner, stated that the project owner had inserted a series of difficult contract conditions during the contractor's invitation to bid; these included squeezing contract time, budget, schedule, and unrealistic construction and delivery time of suppliers.

Therefore it is clear that the contract type, agreement, clauses, invitation to bid and mechanism of contract award all contributed to project delay and scope creep. Figure 4.8 shows the ineffectiveness of the contract award mechanism and strategy used in the aluminum company projects.

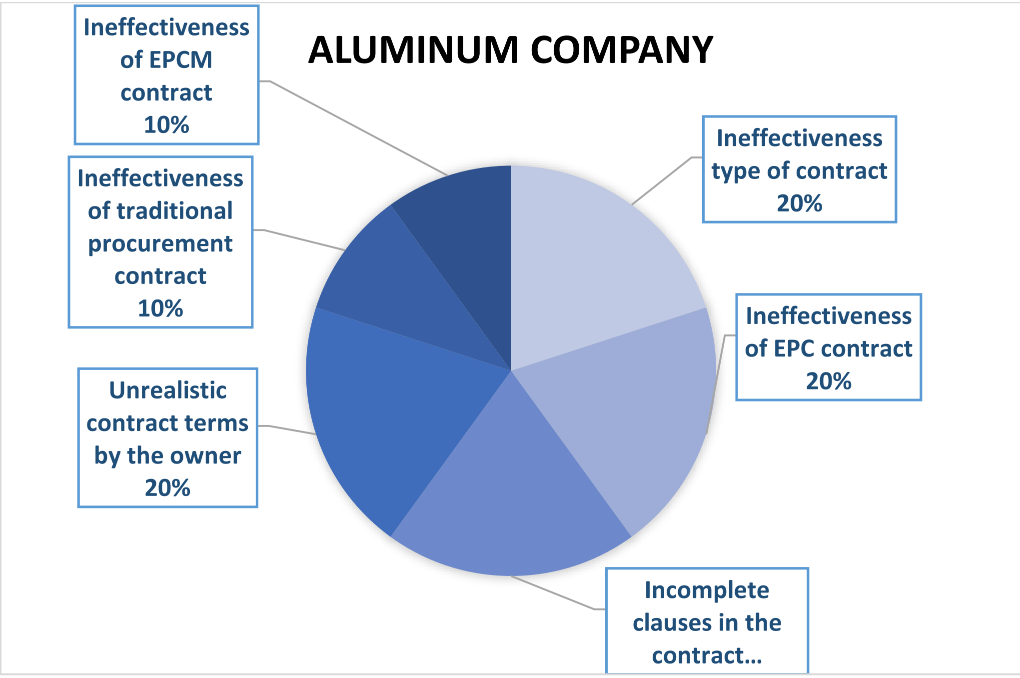


Figure 4.8: The ineffectiveness of contract award mechanism and strategy in mining aluminum company projects

It seems, therefore, that, as shown in Figure 4.8, the aluminum project had faced difficulties with the two types of contracts which were the EPC and the EPCM; there had been incomplete clauses and terms, an ineffective traditional procurement contract and award system and finally unrealistic contract terms by the owner.

4.4.4.3 Headquarter's (Business unit) responses to contract award mechanism and strategy

Interviewees of higher management at the headquarters were asked, too, about the effectiveness of contract award mechanism and strategy for the previous megaprojects. All interviewees agreed that most of company project had used either EPCM or EPC contract. Interviewee 15, director of contracts and procurement, added that the unit rate contract was a third type of contract only used when the project scope was unknown when, for example, the engineering rate and non-estimated quantity of technical items were unknown. Interviewee 15 added that the most important contract clauses for the megaproject had been the performance guarantee, governor law, attribution rule, insurance, acceptance of conditions, testing of technology, change in market and variation procedure. He then highlighted that time, team, market, i.e. booming, location, weather and quality had been the main factors that had affected the course of the project. Both interviewees 14 and 15 stated that the flexibility of the project's contract had largely been unrealized.

It is very clear that the type of contract, clauses, insurance, agreement, market change, project team, contractor, insurance, governor law, attribution rule, location, weather and quality of technology at the conception and prefeasibility phases had all contributed to mega-project delay and scope creep.

In conclusion, the results show that the company had faced difficulties with the contract strategy and clauses. Both the gold and the aluminum companies faced technical hitches with both types of contracts either EPCM or the EPC, but more with the EPCM. Both companies agreed that the traditional procurement system had not been effective. Moreover the gold and aluminum companies agreed that the contract conditions and terms had not been adequate, or as effective as required. Both companies placed part of the blame for contract problems on the owner.

4.4.5 The basic engineering design and detailed engineering design phases (Questions 10, 11–14–28–40, 74 and 76)

4.4.5.1 Gold subsidiary responses to basic and detailed engineering design

The gold company interviewees were asked about the difficulties during the design stages or FEED at the beginning of the mega-project.

Interviewee 2 stated that basic engineering design was the second most important phase for the project after calculating ore quantities and quality. He added that the allocation for Front-end Engineering Design (FEED) and planning from overall capital cost of the project was 30%.

Interviewees 1, 2, 3 and 4 stated that the contractor had handled everything including the design phase due to the project contract strategy. However the internal project management team had conducted three stages of the design revision with the main designer and value management consulting firm. All interviewees agreed that the project had faced hurdles during basic engineering design and detailed engineering design.

Three interviewees, 3, 4 and 5, stated that there had been a lack of technical expertise in technical project management, value engineering and hence the design phase could not be followed up properly with the awarded design company and the professional external technical team (consultant).

The representative of project control, Interviewee 4, added that design process and design approval from board members had taken a long time.

The project manager, Interviewee 5, stated that the design was one of the responsibilities of the main contractor and the delay in submitting design packages had resulted in schedule delay and extra cost. He added that the lack of detailed design and modification had caused delays in inviting construction bidding. He pointed out that the owner's design bidding plan, design bidding time and pre-review time of design before holding the design evaluation workshop had been unsatisfactory. Interviewees 1, 2, 3 and 5 stated that the completion date for some of the projects had been delayed due to the lag of time between project activities.

It is clear from these results that there had been less than optimum efficiency with regards to the basic engineering design caused by design failure or errors during the prefeasibility phase. There had obviously been a lack of an internal design team, an internal value management team with their related technical expertise; in addition there had been a poor bidding plan and lack of review of design conditions. There had also been a lengthy design process and review and a delay in decision-making on the part of the owner and senior management for the three design stages in the prefeasibility and feasibility phases. Figure 4.9 displays the gold company project difficulties at the design phases or FEED.

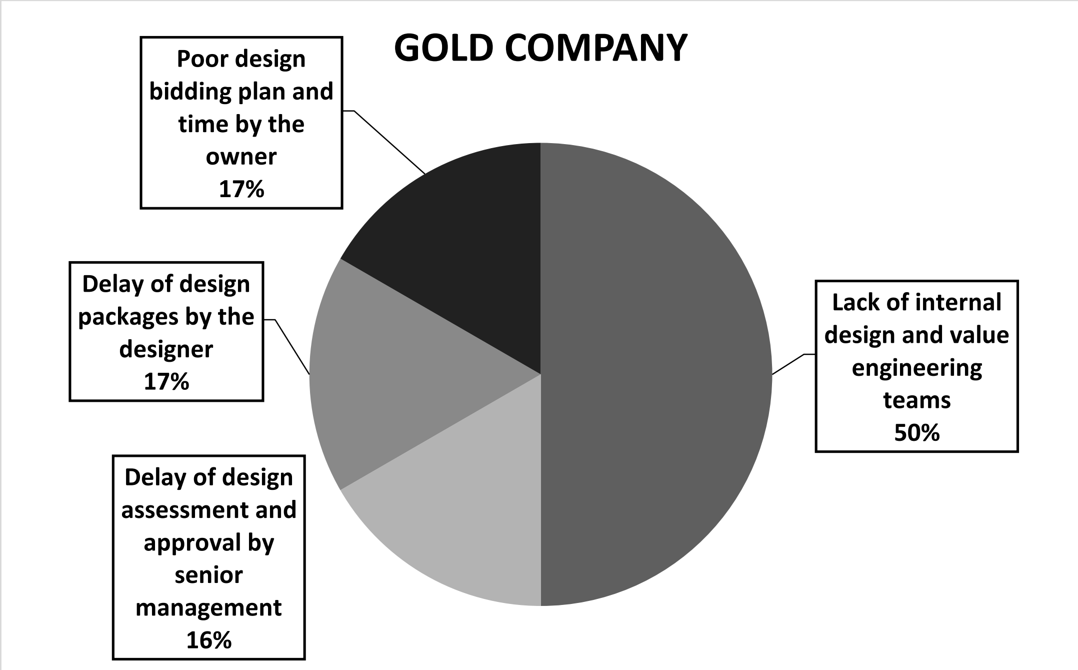


Figure 4.9: The difficulties during the design phases or FEED at the beginning of the gold company mega-project

It seems, therefore, that as demonstrated in Figure 4.9, the gold company had faced technical hitches during the design phases in the prefeasibility and feasibility phases. These difficulties had been a lack of internal design and value engineering teams in the mining field, delayed design assessment and approval by the senior management and delayed design packages by the designer; these in turn had led to project delay especially at the construction phase.

4.4.5.2 Aluminium subsidiary responses to basic and detailed engineering design

The aluminum company interviewees were also asked about the difficulties during the design stages or FEED at the beginning of the mega-project.

Interviewee 8, a project director, stated that the mega-project had had 40 detailed engineering design packages at different times amounting to 50 million man hours. Interviewee 10, a representative of the finance department, explained that design packages had been distributed among the three leading companies and under the supervision of a leading contractor. All Interviewees agreed that the design stages had exceeded the expected time due to many complicated factors. Interviewee 11 and 12 specified that the design delay had occurred due to lack of proper planning.

Interviewee 8 pinpointed the leading designer as being the main cause of the design deficiencies and other causes had been the design changes from prefeasibility phase until the construction phase by the technology provider, the design consultant, the technical project management team and the internal and external technical teams.

Interviewee 8 stated that operation and maintenance teams had not been involved in the design information loop from the early stage of the project. He pointed out, furthermore, that the designer had not considered the importance of fine details in the design of the mega-project such as accurate weather information for the project location.

The results show that there had been missing design details, design changes, delayed designs, noninvolvement of technical expertise in the design phase especially the operation team, production team and maintenance teams, internal project management team at the prefeasibility phase, lack of internal technical expertise and lack of value engineers in the design phase. Figure 4.10 displays the difficulties during the design stages or FEED at the beginning of the aluminum company mega-project.

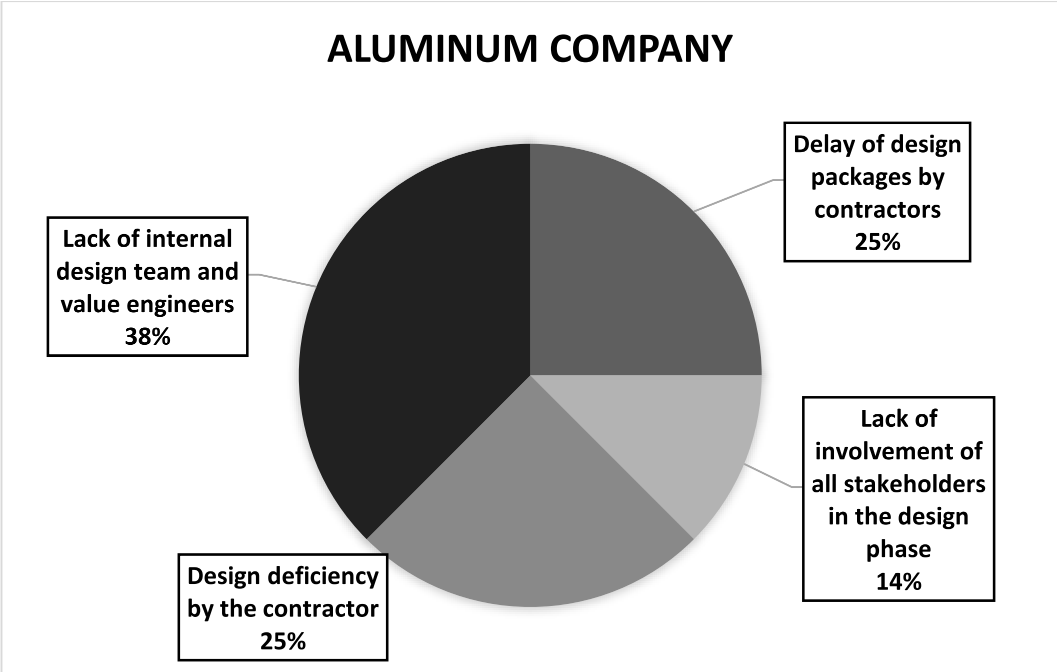


Figure 4.10: The difficulties during the design stages or FEED at the beginning of the aluminum company mega-project

Figure 4.10 shows that the aluminum company had faced technical and nontechnical difficulties during the design phases in the prefeasibility and feasibility phases such as delayed design packages by contractors, noninvolvement of operation and maintenance teams in the design phase, inadequate design by the contractor, lack of internal design team and value engineers and poor planning.

4.4.5.3 Headquarter's (Business unit) responses to basic and detailed engineering design

Higher management interviewees at the headquarters were asked about the difficulties during the design stages or FEED at the beginning of the mega-project.

The representative of project control and risk management, interviewee 14, stated succinctly that most of the stakeholders' input, feedback, and work experience had not considered the inclusion of maintenance and operation teams during design evaluation workshops after they had signed the contract with the leading design company.

Interviewee 15 stated that the project's design and construction had been assigned to different leading firms. Interviewee 13 stated that most of the mega-projects and major project if not all of them had faced difficulties at the detailed design phase.

In conclusion, the results show that both the gold and the aluminum companies agreed that there had been a lack of contribution from an internal design team and value engineering team, and delay in receiving design packages which, when ready, had been found to be inadequate. The gold company results show, moreover, that there had been a delay caused by the higher management in assessing and approving the design assessment, poor design bidding planning and unrealistic conditions placed by the higher management. The aluminum company results show, too, that the operation and maintenance teams had not participated in the design workshops at the prefeasibility and feasibility phases.

4.4.6 Software and tools at the mega-project early stages (Questions 30 to 37)

4.4.6.1 Gold subsidiary responses to mega-project software programs

Interviewees of the gold company were asked about the software programs and tools that had used in the project early stage.

Both Interviewees 1 and 2 stated that they had faced difficulties during the concept phase due to inaccuracy of raw material information and inaccuracy of software programs/tools. Interviewee 1 added that usually the main contractor had taken charge of calculating the quantity and quality due to the expensive price of mining software programs.

Interviewee 2 added that the mining company had needed a user-friendly mining software program, one that was accurate, reliable and could estimate the cost of ore deposits. However, these programs, he added, were expensive.

It seems that lack of an ore deposit calculating software program and project tools may have added to the difficulties experienced by the project stakeholders.

4.4.6.2 Aluminium subsidiary responses to mega-project software programs

The Aluminum company interviewees were asked about the software programs and tools that had used in the project early stage.

A project director, Interviewee 8, stated that the benefits of using software programs are that all of the information is available at the press of a button. Both project partners, Interviewee 11 and 12, stated that the accuracy of ore deposit information including quality and quantity estimation needs to be close to actual cost estimation. Interviewee 11 added that for the mining industry, banks want documents stating the quantities of mineral resources and project life expectancy in order to facilitate any loan. As mentioned previously for the gold subsidiary interviewees, there is a choice of software programs but the cost is high. Generally, though, Interviewee 8 said, the mining programs were considered affordable in the context of the size and the budget of the mega-project.

Interviewee 8 stated that there had been no unified program for the construction phase to bring all the stakeholders or contractors' activities under one click. However, each contractor company, subcontractor and fabricator had its own software programs in every discipline. Moreover it was hard to connect all internal stakeholders' software programs with different departments' programs under one project and one roof.

Interviewee 8 stated that a major drawback of using software programs was the data needed to be maintained regularly, otherwise the tool would be ineffective.

Interviewees 7, 8 and 10 stated that the company itself had lacked cost estimation programs, ore block calculator program and tracking procurement program during the construction phase. However, some of the contractors, he said, had different versions of these kinds of programs but they were not user-friendly. Interviewee 8 added that, for example, the main leading contractor had used a program called 'Matman' to track mega-project procurements at the construction phase. The representative of the finance department, interviewee 10, added that the company had used the traditional comparison of previous projects to estimate the project cost at the prefeasibility and construction phases.

It is clear that there was a lack of ore block data gathering program for project cost estimation at the concept phase, lack of procurement tracking program during the construction phase and lack of IT technicians to run such programs.

4.4.6.3 Headquarter's (Business unit) responses to mega-project software programs

Higher management interviewees were asked about the software programs and tools that had been used in the project early stage.

Interviewee 14 stated that cost estimation and profit are the most important elements for any business. Therefore directors must have accurate information to make their decisions, measure the gross margin, make optimal choices and value the assets. Both Interviewees 13 and 14 stated that the main contractor of engineering, procurement and construction provided the project with 3D building modelling at the concept and prefeasibility stage. Interviewee 14 highlighted that the corporation and its subsidiary used different programs on different levels of project lifecycle such as AutoCAD, a traditional mining software program, traditional risk tools and a traditional cost estimation tool. Both interviewee 13 and 14 added that some of the mining programs were expensive and needed a training budget. The main contractor, too, was responsible for the procurement tracking (interviewee 15).

In conclusion, it was found that the corporation did not use accurate software programs to calculate the quantity of mineral raw materials in the concept phase and before the design phase as a result of the high costs possibly also due to the lack of technicians to run such programs. The company did not use a software program to track project procurements during the construction phases for the same reason. The company had used a traditional tool to estimate the project cost during the prefeasibility phase and construction phase such as cost comparison of the previous projects and equipment.

4.4.7 Value engineering or value management at the prefeasibility and feasibility phases. (Questions 38-41)

4.4.7.1 Gold subsidiary responses to value engineering or value management

Interviewees of the gold company were asked about the value engineering or the value management that had been used in the project early stage.

Interviewee 1 stated that the gold company had complied with international standards for value engineering to evaluate the design HAZOP at three stages. Interviewees 1, 2 and 3 added that the company had earmarked budget for an external value engineering consultant to review and evaluate the design phases with the project designer and the internal project team in order to avoid any difficulties in the advanced stages of the project's life. Interviewees 2 and 4 stated, however, that the internal value management team had lacked experience in value engineering. Possibly the owner's internal team had not obtained the value management international certificate for analysis and workshops and hence had had to rely on the value engineering external consultants. Interviewees 4 and 5 stated that the purpose of value engineering workshops, run by the value engineering consultant, owner and mega-project designer, was to evaluate project items and functions with best cost at three intervals during the project. Interviewees 5 and 6 added that the value engineering for design review and evaluation was important but it did not include all the stakeholders, e.g. the operations staff. It seems that the gold company engineering team had lacked value management knowledge and experience, and hence the reason for being isolated from the value engineering workshops.

4.4.7.2 Aluminium subsidiary responses to value engineering or value management

Two interviewees of the aluminum company had answered the questions about the value engineering or the value management that had been used in the project at the early stage.

Interviewee 8 stated that the percentage of time spent on using value management evaluation at the early stages of the project life cycle was around 51 % to 75 %. It seems that the value management workshops during the project early stages had consumed a large part of the project life cycle. The project partner, interviewee 12, stated that value engineering workshops had focused on cutting cost and had ignored the value of the items. Interviewee 12 added that the value engineering workshops at the megaproject early stage must optimize the project equipment. He stated that value engineering evaluation was a hurdle for projects due to consuming a large part of the design phase.

It seems that the value engineering workshops had become a hurdle instead of facilitating the project process at the early stages and this had occurred due to a lack of a dedicated value engineering team, a lack of defined the internal project management team roles and responsibilities during the design phase.

4.4.7.3 Headquarter's responses to value engineering or value management

Higher management interviewees were asked about the value engineering or the value management that had been used in the project early stage.

Interviewee 14 stated that they considered themselves to be a startup operation company in the world of mining and hence needed to work closely with expertise in every field both internally and externally especially during future projects' prefeasibility and planning phases. Both interviewee 13 and 14 agreed that the company subsidiaries had used value engineering during the design phases with a designated budget.

4.4.8 Mega engineering project cost estimation (Questions 58, 59)

4.4.8.1 Gold subsidiary responses to mega-project cost estimation

Interviewees of the gold company were asked about the meg-project cost estimation procedures and techniques.

Interviewee 2 pointed out that the gold company had depended on the accuracy of the main contractor when estimating the cost of the mine, project and equipment due to the lack of accurate tools, personnel, especially and technicians with expertise in the mining field. He added that the company had needed an accurate and reliable cost estimation for mine and mine equipment to construct the project. The ore information needed accurate resources, budget and mining expertise to make decisions and had been collected by the main contractor in geology and mining fields. Interviewee 5 stated that they had been aware that the project cost estimation could increase at any stage of the project lifecycle and had in fact occurred during the prefeasibility phase due to the delay in submission of project design packages by the designer. Interviewee 3 added that the financial report during the business study in the concept phase was not accurate due to inaccurate calculation of ore deposit at the concept phase.

It seems that, although relying on the expertise of the contractors, it was found that some of the cost estimations at the project early stages had been incorrect.

4.4.8.2 Aluminium subsidiary responses to mega-project cost estimation

Interviewees 7, 8, 10 and 12 of the aluminum company stated that they, too, had used a contractor to estimate the project. The project cost estimation at the project's early stages had been obtained by making a comparison, market study and evaluation of the previous projects, items and technologies, and by calculating the actual ore deposit at the project's early stage. Interviewee 7 stated that a monthly cost estimation was one of the most important parameters to measure the progress of any megaproject at the construction phase and the main project management contractor had provided the owner's finance department with a monthly cost estimation as a reliable benchmark as it was his responsibility according to interviewee 10. The cost estimation report, according to interviewee 10, had been presented to the CEO once every six months before the construction phase and fortnightly during the construction activities in order to avoid project over cost due to any project change orders. He added that during the construction activities, the project contractors' estimates had been the main source of information for the owner and the decision makers. Interviewee 10 added that the project cost estimation had been affected by the project location, site condition, contract strategy and rising energy prices. The finance manager stated that the cost inflation may occur in any mega-project if all the plants and projects belonging to the megaproject start at the same time.

Again, as with the gold company, the main contractor took responsibility for estimating the costs.

It seems, therefore, that the company faced technical and non-technical hurdles when calculating the cost estimation at the conception and construction phases due to the lack of appropriate tools for the cost estimation and due to the reliance on traditional methods and contractors to collect information and to estimate the cost during the conception and construction phases.

4.4.8.3 Headquarter's responses to mega-project cost estimation

The interviewees from headquarters did not mention the contractor having responsibility for estimation of costs as did the interviewees from the gold and aluminum subsidiaries. Instead they explained how important cost estimation is. For example, Interviewee 14, the director in the headquarters, stated that cost estimation and profit are the most important factors for any project and an accurate cost estimation method helps decision makers of projects to visualize the project details, to measure the gross margin, to make optimal choices, to value the assets and to manage the projects successfully by assigning resources and developing a schedule. Interviewee 13 added that project cost estimation in the mining field had relied heavily on the volume of ore deposit calculations at the conception phase.

4.4.9 Mega engineering projects: function analysis (Questions 79 to 84)

Only the gold subsidiary and the aluminum subsidiary interviewees' responses to the technical questions such as function analysis at the conception and prefeasibility phases.

4.4.9.1 Gold subsidiary responses to how function analysis had been used at the early stages of the project cycle

Interviewees of the gold company were asked about project function analysis.

All the interviewees agreed that the project function analysis had been used at the early stages. Interviewee 2 stated that the gold company team had spent 30% of the project time allotted in the early stages on analysis of the technical items. Interviewees 1, 2, 3 and 4 explained how analysis had been conducted and that had been through the use of numerical analysis and data evaluation through workshops and meetings to compare the alternatives. However, despite the function analysis, Interviewee 3 pointed out that the project management department had received an inaccurate financial model analysis report from the higher management finance department, which was not around +-10. Interviewee 2 pointed out, moreover, that during the construction phase they had discovered that there had been items which had not been considered in the function analysis.

It seems that, although, function analysis had taken place, there had still been inaccurate information passed to the internal project management department.

4.4.9.2 Aluminium subsidiary responses to function analysis at the early stages of the project cycle

With regard to the aluminum company, it, too, had used function analysis at the early stages; according to interview 8, 26% - 50% of time had been allotted to the analysis of technical items especially before and during the design stages.

Both interviewees 8 and 11 stated that technical workshops and comparative evaluation were the techniques used for function analysis to compare the alternatives. Interviewee 8 added that sometimes external stakeholders and project objectives had dictated requirements that had had to be met regardless of the analysis. He pointed out the selection of functions for the project had been through the use of life cycle cost models.

It is clear that both the gold and aluminum subsidiaries used similar traditional techniques to analysis project functions and they depend heavily on the contractor and consultant to analysis the project functions.

4.4.10 Mega engineering project team during conceptual or initiation phase (Questions 37, 69 - 77)

4.4.10.1 Gold subsidiary responses regarding efficiency of the mega-project team at the early phases

Interviewees of the gold company were asked about the project internal team at the early phases.

The project had been run by the Vice President of project management from headquarters and the CEO of the subsidiary (Vice president of the company). The execution team operated under these two Vice Presidents. Interviewees 2, 3 and 4 stated that the contractor had managed the project phases from the prefeasibility phase until the delivery phase due to the contract strategy and had liaised with the internal project management team (execution team). However, during the design phases, according to interviewee 2, the company had had a lack of internal technical project management staff to evaluate the project design with the designer company. He added that the project had a lack of technical team to collect the raw material data, lack of technical team to implement the project and lack of local operators in the mining field to run the projects. Interviewee 6 added that the operation team had not liaised with the internal and external project teams during the design phase at the early stages of the project. Interviewee 4 stated that internal execution team had lacked experience in mining equipment evaluation and design. Interviewee 2 added that the internal execution team had lacked awareness or knowledge about this mining project. Both interviewee 1 and 2 stated that the project external teams had had a direct influence on design and ore calculation.

It seems therefore that efficiency had been compromised due to the company's lack of mining expertise in technical project management, design, value engineering, construction and operation. There was also a lack of project definition, inconsistency of implementer's roles on the project, poor definition of project management team responsibilities and individual job descriptions.

4.4.10.2 Aluminium subsidiary responses regarding efficiency of the mega-project team at the early phases

When asked about the project internal team at the early phases, the aluminum company interviewees' responses were considerably different to those of the gold company interviewees.

Interviewee 8 stated that the size of the internal and external mega-project management team was around 80 to 120 members. Interviewees 7, 8 9 and 10 stated that the megaproject had lacked technical expertise during different project phases especially the design phase. Interviewee 10 clarified that the mega-project had had five leading companies and five project management teams, all working under the management of the main mega-project contractor, adding that most of the internal project management teams had not participated in the design review workshops at the prefeasibility and feasibility phases. It seems that the contract type was EPCM; thus the project design liability had rested with the designer and consultants.

Interviewee 10 added that the small number of allocated internal project team had impacted negatively on the effectiveness of project and process. Interviewee 12 stressed the importance of that honesty and integrity of top management and project team members during the project lifecycle especially at the conception, prefeasibility phases and during procurements and the awarding of contracts.

The responses clearly affirmed that the company had had internal teams who had insufficient technical and non-technical expertise in the mining field.

4.4.10.3 Headquarter's responses with regard to efficiency of the mega-project team at the early phases

Higher management interviewees were asked about the project team at the early phases.

Interviewee 14 stated that each subsidiary of the company had many different sized projects and thus an internal project management team is very important. He added that the company had had an external project management team and also had its own small internal technical team. He stated that there had been a lack of expertise in each subsidiary. Interviewee 13 explained that employees had joined the megaproject to gain more experience. The fact that employees wished to gain experience demonstrates their lack of experience and possibly adequate knowledge in mining field at early project stages even if they had project management execution experience in oil, gas and petrochemical projects.

4.4.11 Mega engineering project: market condition and external factors affecting the mega-project (Questions 2, 61-64)

4.4.11.1 Gold subsidiary responses to market conditions and external factors affecting the project

Interviewees of the gold company provided varying responses with regard to market conditions and external factors affecting the mega-project.

External factors had related to the market boom and government procedures. On account of the market boom at the time, there had been a shortage of manpower at the construction phase (Interviewee 3). Interviewee 4 added that the market boom had also caused logistical difficulties for the contractors who had had to operate in remote areas. It had been difficult to find construction companies, subcontractors, fabricators, manpower such as discipline engineers and project engineers and qualified experts in the mining field to supervise and manage the new projects in the remote sites and these factors had led to delays (Interviewees 3 and 5). Interviewee 5 added that, for these reasons, the company and the gold and the aluminum subsidiaries had been forced to deal with Asian companies which considered as a new and outlandish to the local market and perhaps the reason for this was due to political relations between the two countries, although there had still been a shortage of qualified manpower and expertise, dealing with Asian companies complicate the project situation due to the lack of commitment to international standards.

Both interviewees 1 and 2 highlighted the fact that lack of government cooperation had hindered the progress of the project implementation at some stages of the project lifecycle especially in terms of the issuance of the project license.

In conclusion, many factors had affected the megaproject: the market boom had led to a lack of a variety of qualified personnel; especially with regards to the remote sites, had also been affected at the early stages and before the construction phase.

4.4.11.2 Aluminium subsidiary responses to market conditions and external factors affecting the project

The aluminum company interviewees when asked about the market conditions and external factors during project early stages provided responses that included many of the factors provided by the gold company e.g. issuing project licenses by government, lack of government cooperation, and lack of manpower, impose new contractor on the subsidiaries projects (interviewees 8 and 9). Interviewee 7 stated that the company was a new operational company that was driven by opportunity and had a long-term product. Interviewee 9 added that the political stability is an extremely important and there were political instability in the region around the project and could effect on the mega-project especially at the point when the company had a lack of advanced technology and technical expertise. Interviewee 10 stated that market study was an important for cost estimation and market booming had led to increased project contracts price.

These interviewees, therefore, highlighted uncertainty of market, uncertainty of government cooperation, uncertainty of the labor law and possibility of changing at any time, imposing unqualified contractors on the projects during the conception phase, design and construction, preoccupation of top companies in field of manufacturing, project management and mining with other project in the region due to local and regional market boom.

4.4.11.3 Headquarter’s responses to market conditions and external factors affecting the project

Higher management interviewees were asked about the market condition and external factors during project early stages. However their answer were

Interviewee 14 stated that regarding the products and new markets, if the subsidiary want to obtain a project lone for the construction phase, it needs to sell out the product and to provide banks with a proof for the volume of ore quantity. Moreover sometimes the subsidiary needs expert leading companies in marketing field to look for a new customers (countries) for the company products.

He added that some of the projects had faced a lack of government cooperation (e.g. licenses had been delayed) and change in local market was one of the most important contract clauses for their mega-projects. Interviewee 15 added that market conditions had been one of the factors affecting the choice of the type of contract and the price (which would be increased).

The main external factors related to the market that had affected the project had been the government regulations and a lack of proper cooperation (e.g. delays in providing licenses), bank loans, product marketing (geographical area, customer type), lacked of construction contractor at the market boom, lacked of marketing experience to sell the products, lacked of expertise in the mining fields.

4.4.12 Mega engineering project: location and logistics (Questions 22, 67)

4.4.12.1 Gold subsidiary responses to mega-project location and logistics at the conception phase

Interviewees of the gold company were asked about the megaproject location and logistics.

Interviewees 1, 2 and 6 agreed that the company had faced serious difficulties with the location, utilities, logistics and mobilization of contractors to the project location. Interviewee 2 added that the location of the project and logistics were two of many factors that had affected the success of the project. Interviewee 6 stated that the logistical difficulties related to the project location in the remote area had been considered a major risk of the project construction. The project developer, interviewee 2, stated that the project had lacked effective communication with the contractor and subcontractor at the project location during the site preparation stage.

The responses indicate that there had been difficulties related to utilities (water and electricity), logistics and mobilization of the contractor the remote area, communication with site contractor especially the Asian companies. Therefore, It obvious that the project location, utilities, mobilization of manpower considered as major hurdles for the decision maker at pre-project stage, the conception and prefeasibility phases pointing to a lack of management plan in the project site.

4.4.12.2 Aluminium subsidiary responses to mega-project location and logistics

The aluminum company was located in a different location from the gold projects. The aluminum company interviewees were asked about the logistics in regards to their location.

Interviewee 8 stated that the megaproject was a from-mine-to-port project or an integrated complex that had been located in a remote area and lacked all the necessities of life. He added that the project contained mine, plants, train, port, roads, bridges, electricity station and buildings. He stated that the mega-project had faced risks and difficulties in everything from roads to electricity to water to manpower even in communication with authorities. Interviewee 9 stated, moreover, that during the construction phase, the project had communication hurdles with the herders or the nomads who had inhabited the project site and had had to provide compensation adding to unexpected cost (as the herders lived a nomadic lifestyle they had not been on the site at the time of planning). Providing compensation was, however, not well received as these people wished to be able to travel from one location to another. He added that the project had also faced years of interface difficulties with five governmental authorities around the project location and had resulted in additional expenditure during the construction phase for building bridges, fences and roads. The project director, interviewee 9, stated that the project had had difficulties obtaining project licenses from the government due to the presence of other owners around the project location (as mentioned also by the gold company interviewees) as well as the security issues related to the project. The project director, interviewee 8, stated that the factors (e.g. lack of facilities and transport) related to the remote location were the main difficulties affecting the success of the project.

Hence, it is clear that many difficulties, mainly related to location and logistics that had had to be overcome during the implementation of the project. From the responses it can be concluded that there had been delays in government delivery of project licenses during the early stages of the project, lack of government cooperation, lack of governmental authorities' cooperation, lack of management interface plan, poor communication between the company, authorities and local community around the project site, and logistical difficulties such as transportation to/from the remote area.

4.4.12.3 Headquarter’s responses to mega-project location and logistics

Higher management interviewees were asked about the megaproject location and logistics.

Interviewee 14 stated that it is extremely important to have a project next to the facilities and resources, but in their mining projects all of the ore was located in remote areas impacting, according to interviewee 13, contractor, logistics, construction and product. Interviewee 15 explained that the project location had affected the choice of type of contract and labor costs. .

From the responses it can be concluded that the selection of project site had a direct and indirect impact on all project aspects and costs. It also had impacted on the selection of the contractor and contract price, high labor cost, the prices of materials, transportation, and price of utility, high cost of staff salary and on the final product. The project had faced difficulties finding contractors to work in remote areas during regional market boom and also logistical hurdles.

4.4.13 The mega engineering project: the impacts of linguistic diversity and internal culture (Questions 65, 78)

4.4.13.1 Gold subsidiary responses to the impact of linguistic diversity and internal culture

Interviewees of the gold company were asked about the impact of cultural diversity of different contractors on the project.

Interviewee 2 stated that the project culture within the organization during the product development stage was a very important factor for project success. The company project team had worked closely with different international leading companies in the mining field that had different languages and cultures. However, communication had only taken place with regards to the contract and international technical standards. He added that the project did not have an effective management plan particularly for the remote area at the site preparation phase and construction phase as well. Moreover, Interviewees 1, 2 and 4 stated that the internal project team had faced language barriers when working with Asian companies since the Asian companies had not acknowledged the international technical standards and instead had used their own internal technical standards. According to Interviewee 4 Asian companies had also difficulties with the English language. Interviewee 6 added that the project had not specified how communication would take place within the departments and with the contractors.

Responses clearly indicated that the language difficulties had not been planned for (even though the contract had stated English language would be the language of communication) and this had led to lack of consistency in the use of technical standards especially during the prefeasibility and feasibility phases and then in the construction phase.

4.4.13.2 Aluminium subsidiary responses to the impact of linguistic diversity linguistic divers and internal culture

The aluminum company interviewees were asked about the impact of cultural diversity of different contractors on the project.

Interviewee 8 stated that the cultural factors (e.g. language, communication) had impacted on the effectiveness of project process due to the diversity of work, the multiplicity of companies, contracts, vendors, suppliers, fabricators and project teams from different companies starting from the prefeasibility phase toward the construction phase. However due to the existence of sound expertise, there had been no negative impacts for the planning or the construction apart from a lack of cooperation among departments and mega-project teams particularly during the construction activities.

The cultural factors impacting on the project implementation, according to all of the interviewees, was a lack of communication plan to enable effective communication among the mega-project inter-departmental teams, higher management, contractors and the internal project teams. This had caused delays.

4.4.13.3 Headquarter's responses to the impact of linguistic diversity linguistic divers and internal culture

Higher management indicated that there had been both positive and negative impacts from the cultural diversity. Interviewee 14 stated that, due to working with companies from a variety of countries, international standards and contract had been adhered to; this response is different from that of the aluminum subsidiary. Interviewee 14 added that the cultural diversity had in fact helped to provide the different expertise required for the projects although he conceded there had still been a need for more expertise. Interviewee 15 explained that, although cultural diversity and project facilities at site location were items in one of the contract clauses that had been negotiated beforehand with several contractors, negative impacts had been found related in particular to language barriers.

4.4.14 Mega engineering projects: impact of leadership: board members, higher management and the company management (Questions 10, 19, 23, 28, 51,62)

4.4.14.1 Gold subsidiary responses to the impact of leadership on the project progress

Interviewee 1 from the gold company stated that the organization chart had affected the project's progression due to the conflict of responsibilities. Interviewees 2 and 4 stated that the higher management had delayed the evaluation process and final approval especially in the design phases. In fact, according to Interviewee 3, the project owner had been the main cause of the project delay. Interviewee 4 explained further that there had been poor communication between the main contractor and internal project team at the prefeasibility and feasibility phases and also a lack of understanding between the higher management and project teams. Five interviewees 1, 2, 3, 4 and 5 agreed that the project had suffered from lack of proper communication from top to bottom, and government authorities had delayed project licenses. Both interviewees 1 and 4 agreed that the project team had experienced a lack of assigned authority. Interviewee 5 stated that the project had lacked proper planning and job descriptions had not been supplied for each member of internal project management team.

It seems that the company had suffered from a lack of effective leadership as shown by the responses with regard to lack of inter-departmental communication, lack of a proper organizational matrix designating structure and responsibilities and job descriptions. The government also had contributed to the delay through slow approval of licenses.

4.4.14.2 Aluminium subsidiary responses to the impact of project leadership on the project progress

When the aluminum company interviewees were asked about the impact of higher management on the project activities they also mentioned a lack of effective leadership, lack of inter-departmental communication and lack of government cooperation.

Interviewees 7, 8 and 9, for example, stated that the lack of cooperation between the external and internal authorities had impacted on the project progress time and had caused cost overrun. Interviewee 9 supplied examples – issuing of permits and licenses. Interviewee 8 stated that specifically, due to the lack of clarity on how communication was to take place among the stakeholders, the number of meeting requests had increased and had caused waste of project time. Higher management according to the project partner, interviewee 12, had also tried to squeeze the contract conditions, had not defined the project properly, had not considered the construction time allowance within -+10 of the project time and generally had not planned well or spent money-wisely. He implied that the leadership needed to have honesty and integrity.

It is obvious there had been serious hurdles that had negatively impacted on the project from the leadership side and had led to increased project costs and delays in the project delivery time.

4.4.14.3 Headquarter's responses to the impact of project leadership on the project progress

In line with responses from interviewees from the aluminum subsidiary, interviewee 13 from the headquarters stated that some projects in different subsidiaries had lacked project definition and job descriptions, and these difficulties had led to expertise leaving the company and had caused changes take place in management. Also substantiating responses from the aluminum subsidiary, interviewee 14 stated that there had been a lack of communication among the stakeholders due to lack of compliance with the communication plan, if there was any. Interviewee 13 stated that imposition of board members' decisions on the company's planning and implementation had affected the project progress.

Responses of headquarters substantiated those of the aluminum subsidiary in that there had been poor project planning, poor project definition, lack of job descriptions and lack of an effective communication plan. Due in part to these difficulties, staff with expertise had left the company, adding to delays.

In conclusion, this analysis shows that many difficulties had been experienced during the project phases especially at the conception and prefeasibility phases and had affected the construction activities and these difficulties had led to delays. There was agreement among headquarters, the gold subsidiary and aluminum subsidiary that difficulties had included a lack of understanding of the mega-project processes and the scope at the early stages of the project until the end of the prefeasibility phase, unstoppable extra costs of the technical and nontechnical scope creep and change orders, a lack of definition ,understanding and categorizing of stage-gate deliverables for mining projects, a lack of technical expertise in the mining field, inappropriate internal project management team roles and responsibilities for the mining field, absence of value management engineers and mining engineers, poor project definition and planning, a lack of higher management cooperation and communication, a lack of cooperation between all of the stakeholders at the design and construction phases, deficiencies in the design packages, lack of an effective communication plan, lack of interface plan, difficulties with contract strategy, clauses and traditional procurement system, lack of job descriptions, lack of cost estimation accuracy due to the inaccurate calculation of ore deposit at the concept phase, lack of procurement tracking program at the construction phase and lack of modern cost estimation program during the feasibility phase and construction phase. In addition, the selection of project site had had a direct and indirect impact on all project costs such as contract price, labor cost, price of materials, transportation, utility price, staff salary and on the final product. Finally, a lack of consistency in the use of technical standards especially during the prefeasibility and feasibility had occurred due to language barriers. The next chapter, Chapter Five, discusses the implications of these results.

CHAPTER FIVE

5 DISCUSSION

5.1 Introduction

This chapter presents a review of the findings of this study and a discussion of the findings and their implications. This study was designed to evaluate the project management processes used in two megaproject in Saudi Arabia in order to devise an improved management process framework at mega-project preplanning, initiation, prefeasibility, feasibility and construction phases. The main aim of this research was to study and evaluate the extent to which stage-gate project management process and traditional project management process are being applied in development phase of (mega) projects and seek to develop a structured approach (a hybrid model) applicable to future mega-project activity efficiencies. Many project management professionals, practitioners in the field of industry, academia and developers of software engineering tools have lack the holistic view and understanding of mega-projects project process starting from preplanning phase; this research study was designed to assess, clarify and evaluate mega-projects processes especially at the preplanning phase and at the board members, executive level and even at project management team level. The research questions are derived from the research literature, but they could come from current business practice or your initiative hunches (Marshall and Rossman 2014). The questions this study sought to address were:

1- Is there a relationship between project management process, scope creep, value management, contractual arrangement, procurement and software programs generally in terms of speed up project delivery?

2- Are traditional project management process adequately addressing the key variables of “scope” as applied to mega-project?

3- Can current stage-gate project management practices and activities be structured objectively for more efficient realization of mining mega-project briefs?

4- Are any of the constituents of antecedents of stage-gate project management applied in the medium and small scale companies, albeit under the guise of more traditional approaches?

5- Can stage-gate project management practices and activities be structured objectively for a more efficient realization of mega-project briefs?

6- Identify the characteristics of successful mega integrated project for medium mining operation firm that is rich of natural resource and lack of project management team.

7- Is there a relationship between size of the mega-project and project delay?

8- Can mega-project shorten to less stage-gate phases in order to save money, time and effort during the initial stages of the project?

The data collection of this research was collected from mega-project management staff in the mining construction industry and two case-business studies. The findings from this study suggested that the mega-project management processes, tools and techniques in this mining organization delayed the product deliverable schedule during the preplanning phase, prefeasibility phases and increased project cost through ongoing scope creep and change order during the design stages and the execution phase; this finding is supported by the study of (Whyte 2014) of 15 construction projects where the findings showed that the project deficiencies came from process and leadership - 43% and 38% respectively, totaling a contribution of 81% to project deficiency; unknown internal factors and unknown external factors contributed 11%

and 5% respectively. Somewhat divergent findings from Whyte's study are noted in the following discussion.

Cost and time increased beyond schedule during the preplanning, the conception, the prefeasibility, the feasibility and the construction phases and affected the output of each stage by using frequent change orders and iterations of activities and tasks starting with basic design, then detailed design, until the end of the construction phase and beginning of start-up. Details of the impacts, as stated by the interviewees, and further possible impacts are now discussed.

5.2 Impacts of Stage-Gate Process on Project Lifecycle

The two mega-projects of this study had faced obstacles with the stage-gate process at all stages and ineffectiveness of the traditional project management processes in the early preplanning stage, a lack of defining and understanding of stage-gate deliverables for mining projects, difficulties implementing the stage-gate process for mineral project and process, inappropriate linking of the stage-gate process to key stage deliverables and some disciplines, a lack of higher management cooperation and length of time of approval process and design assessment approval by higher management (gate-keeper), a lack of allotted time for the design evaluation stage after receiving design packages from the designer, a lack of cooperation and communication between contractors (designer-constructer) and the owner's project management team. 43% of aluminum megaproject interviewees, 34% of higher management and 17% of gold interviewees, had attributed the mega-project hurdles to the stage-gate process. Karlström and Runeson (2006) found that the stage-gate process enabled coordination and communication of functions with other development teams and senior management; however, in our study, the stage-gate process had not yet contributed to effective coordination among the various teams. This was possibly because of lack of understanding of the stage gate process for mining projects but this understanding could improve (recommendations are made in the following chapter to aid improvement).

The ineffective use of the stage-gate process and activities is likely to consume project management team effort, time and budget because of the intensive meetings and workshops required to reschedule or rework some of the deliverables. At the time of this study there had been delays in the project management team decision-making and delays in final approval from higher management (gate-keeper) at each stage resulting in rescheduling of each stage or phase of activities. Re-evaluation was required of each phase of the stage-gate process; increased material costs and delays to the project construction phase resulted. Van Der Weijde (2008) found that project development phases or process improved cost predictability, enhanced cost effectiveness, better schedule predictability, faster project delivery, optimised scope, and better operability and safety performance. The implementation of megaprojects that involved different organizations may affect project management processes (Fellows and Liu, 2013).

The CEO of the aluminum subsidiary who had had broad experience with petrochemical projects and stage-gate process in petrochemical mega-projects emphasized the importance of the stage-gate process and the need to link the stage-gate process to the right department and team. Both mega-project senior management and higher management had had broad work experience in the project management fields in oil, gas and petrochemical but they had found difficulty in applying the stage-gate process in the mining project; this was possibly due to the different mining processes and these difficulties had led, as mentioned, to project delay and cost overrun. Without a clearly defined process, inadequate or incorrect planning and scheduling are likely to occur because of inaccurate input parameters, inadequate techniques being used, inaccurate resources being planned for, incorrect estimation, tight schedules, and design inadequacies. Other impacts could be required replacement of equipment due to rework, delay in replacing items, project schedule delay, and increased cost of equipment and finally extra cost for the whole project. Anglo American (2009) found that only 12.5% of mega-projects in the mining field actually deliver on the benefits that were originally anticipated.

Lack of stage-gate process clarity among stakeholders, departments and contractors at the project development phase and then execution phase could lead to serious risks such as increased project direct and indirect costs starting from preplanning phase then it moves to the basic design phase and detailed design through to construction activities. Aitken and Crawford (2012) found that project development process plays a crucial role in corporate strategy via the delivery of benefits through project management to enable long term business growth delivered through the operating facilities we extract value from today. Unclear stage-gate processes at preplanning and execution phases may also increase conflict among departments, increase iteration of activities or rework at each phase, delay contracting and tendering process, decrease the accuracy of each objective in the prefeasibility and feasibility stage gate stages, increase the likelihood of change orders, decrease accuracy of cost estimation of every stage, lead to poor project start-up plan and possible mechanical failure at the end of the construction phase.

The lack of awareness of mega-project processes starting from the conception phase may result in absence of standards and technical codes that can hinder the interdisciplinary communication among stakeholders and lead to extra cost starting from basic design in the form of iteration or re-design. Another key fact to remember, unclear stage-gate process may affect escalating costs of materials and push out material delivery times due to shortage of construction materials and high demand and these can, in turn, result in delay of project start-up, escalating the capital cost.

Lack of understanding of stage-gate processes and deliverables may also mislead cost estimators and cause inadequate cost control starting from the conception and prefeasibility phases and may affect capital cost of the project; poor cost estimation reporting may lead to a delay in identifying the cost overrun, thereby reducing the ability to put in place any remedies.

Before the prefeasibility phase, if the documentation and correct project specification (both technical and functional) are not ready and delivered on time to facilitate the ongoing project deployment phase including design tasks and later construction activities of the mega-project and if the documentation including the specifications is in conflict with pre-existing documentation or not available in accordance with schedule requirements, the schedule may slip or remedial works may be required. Unidentified technical issues for process and plants at the prefeasibility phase could affect design and result in design rework, extra budget and project delay. Mackenzie and Cusworth (2007) found that if the project does not align with the expected benefits or strategic objectives, or it does not provide business confidence at any stage of the project review cycle, the study may need to return to the start of the phase, or be returned to the key value-adding phases of concept and pre-feasibility.

Unclear understandings of the stage-gate processes at the project development and prefeasibility phases due to lack of expertise of the personnel involved may cause delay of project completion. Al-Kharashi and Skitmore (2009) found that that the main cause of delay in Saudi Arabia public projects is the lack of qualified and experienced personnel. Moreover, with regard to personnel experience, this study found that lack of technical and project management experience delayed project study at preplanning phase and decision maker approvals. Similarly lack of experience delayed a mega project in India – the launch of the first domestic aircraft carrier in 2013 even though the preparation for this mega-project had started in 2008 (LaGrone 2015). These unclear understandings could lead also to a focus only on short term project delivery rather than on a long term business strategy, additional costs of attracting personnel and delay in project start-up. The consequence of these delays could be loss of key technical expertise already hired due to frustrations experienced with the lack of clarity of the processes.

There was, moreover, a lack of a proper classification schema for the stage-gate process to classify activities under each phase due to, as previously mentioned, lack of technical expertise in the mining field. The scarcity of expertise may result in a dilution of the quality of the labor and associated reduction in labor productivity, unsafe construction and start-up, and may, ultimately, lead to project failure. During the annual leave cycle when there is even less expertise, important project functions may not continue consistently and hence delays to the project schedule could result.

Although the international project management companies had their own expert personnel who could plan, supervise and implement the mega-projects, the final decisions in the stage-gate process, classification of the project activities and moving activities from one phase to another, were in the hands of the owner or the senior management. As 22% of the gold project interviewees had highlighted, higher management, 'gate keeper' of stage-gate process, had delayed design assessment approval at the prefeasibility and feasibility phases. Zou et al (2006) identified time related risks that influence project delivery, which are: excessive approval procedures in administrative government departments, incomplete approval and other documents, unsuitable program planning and inadequate program scheduling, design variations,

variations by the client. Both megaprojects' interviewees highlighted the delay of process approval from the higher management; this delay in approvals could have been due to lack of experience of the higher management in the mining field. This lack of making a final decision on project development phase; the basic design stage could lead to delays in transitioning the project to the detailed design stage and in turn result in delays in project procurements that require a long delivery time, especially long lead items such as machinery that could cause substantial problems in start-up of the project; the delay in project schedule, especially the construction activities, may be further impacted by rising costs of materials, fabricators, purchases, labors, contract prices, exchange rates; in addition, as mentioned by all the interviewees, there could be impacts from changes in government regulations (labor and licenses) resulting in delayed decision-making in the initial stages of the project. Ahmed et al. (2003) found that the most critical causes that delay USA-Florida projects were permits approval, decision and approval during project development stage including design, incomplete documents, change order, changes in drawings, and changes in specifications. Peter Morris (2011:7) stated 'It is evident from an extensive amount of research that management of the front-end definitional stages of projects is of overwhelming importance to their ultimate outcome yet we have little empirical data to suggest how best management competencies here should be improved'. Richard Wittig (2013) found that the current mega mining project practices require an integrated framework for stage-gate phases through project development to reduce cost and schedule overrun. The next-generation of stage-gate systems is to accelerate projects and some leading companies are working on fast track version of stage gate (Cooper, 2014).

5.3 Impacts of Megaproject Definition at the Preplanning Phase on Project Lifecycle

There were similarities between the two mega-project case studies of the gold and the aluminum subsidiaries in the preplanning, planning phases and construction during the project definition and prefeasibility phases despite the differences in scope definition, management, project process, planning, and technology used, the project management teams, sites, contractors. Perhaps the reason behind the similarities is the common policies of the shareholders or the parent company, which play a key role in the advanced preplanning for the megaprojects before their delivery to the heads of the subsidiaries. The parent company projects are subject to the decisions issued by the Ministry of Petroleum and Minerals, which in turn are subject to the decisions issued by the Ministry of Economy and Planning after offering investment opportunities to leading international companies. Before the conception phase, the parent company and shareholders imposed names of leading international companies on the subsidiaries to be considered for the conception phase. Politics can interfere with business decisions. As Flyvbjerg (2005) stated, political, technical, and cognitive reasons can impact on investment decisions.

The preplanning phase can also have impacts on the progress of the project. A business partnership occurs either before the conception phase or with the technology provider before the design process or during the other construction phases. In the case of partnership before initiating the conception phase, a leading company in the mining field and the mining subsidiary sign a memorandum of understanding and state how the expenses are to be shared and prepare a prefeasibility report. In this study it was found that, after preparing only a few of the reports, the international personnel withdrew from the project due to commercial rivalry, competition or political issues.

In this case the megaproject owner lost money and time and had to renew efforts to proceed by searching for another partner or technology provider. Jordan et al. (1988) argued that 15% of the time and resources in projects should be spent on front-end work, whereas Miller and Lessard (2001) suggested up to 35% thus demonstrating that, in this project, too much time and money had been allocated to the pre-planning phase. Although cost uncertainty is higher in the early stages, it too is tangible and manageable (Samset and Volden 2015).

At the preplanning phase of aluminum project, the owner was reliant on the technology provider who considered other projects around the world at the same time instead of committing 100% to this one project; the technology provider who had carried out a project study under the supervision of the owner had needed to recruit local engineers and to transfer its own professional staff from other projects around the world to new project sites and this process led to depletion of the proposed budget and time at the conception phase; leading company professional staff salaries were calculated on a monthly salary rate not on a unit rate; in addition professional staff needed accommodation, transportation, as well as stability before embarking on a study of the project. Furthermore, late arrival of some leading company staff and late engagement of staff to project activities consumed much of the conception phase time and budget. This led in turn to delayed project study phase and significantly increased project costs including materials and equipment while the owner was sourcing another technology provider. Furthermore, due to the consumption of funds and time at this stage, and to avoid further expenses, the project owner imposed the previously constructed prefeasibility report of the former technology provider on a new technology provider with some minor edits (material prices). The new technology provider’s changes affected the project lifecycle. The project owner needed to re-assess the financial aspects of the project due to the time difference between the time of use of the prefeasibility study, material prices (i.e. cement and iron), energy prices (i.e. gas and oil) and changes to the primary contracts with manufacturers (i.e. pipelines and heat exchangers). Kaming et al. (1997) found that the major factors influencing cost overrun are: project degree of complexity, material cost increase due to inflation, inaccurate material estimation.

During the interviews, the owner project management teams in the gold and aluminum subsidiaries almost unanimously stated they there were misunderstandings with regard to mega-project definitions, concepts, processes and they lacked of defining the meaning of mega-project at the pre-evaluation phase and prefeasibility phase, although both the owner that represents the business and non-function side and the main leading project management contractors represents technical side yet mega-project process still an obstacle to decision-makers in project development phase which often extend to three years. The reasons for that may go back to different causes as some was mentioned by interviewees such as a full dependence on the technology provider or partner, the lack of technical team in mining field, internal project management team or due to the type of contract (EPCM or EPC), contract terms and condition of supervision and control. Thus it is clear from these findings that there was insufficient pre-planning carried out. Samset and Haavaldsen (1999) suggested that most of the problems ought to be met early, i.e. in the pre-study phase. These findings are in line with recent studies which have highlighted the front-end phase of projects including the project definition, as important for ensuring strategic project success (Merrow, 2011; Morris, 2013). Unlike other mega-projects, the mining mega-project, bank loans and project financial report before the construction phase were based mainly on the accurate calculation of the quantity of the mineral resource and water to extract it before embarking on project evaluation during the conception phase.

Lack of knowledge and coordination were two main aspects impeding progress of this study and these findings are in line with the study of Duimering et al. (2006) who found that communication, coordination, knowledge and problem solving effect on the project team of new project development tasks and activities structure. They suggested that ‘decomposition of project tasks to minimize interdependence between tasks and the flexible adaptation of new product development task structures as new forms of task interdependence are recognized during the development process’ (p. 239).

The two subsidiaries had used the traditional project management process as a mega-project process except in the design phase which had used the stage-gate process, while the leading project management firm, and construction companies had used the stage-gate process, and the pre-study phase had been ignored. Morris (1997) found, too, that project management had an extremely narrow focus, reflected only in the project life cycle, and ignored pre-project analysis and evaluation. He noted that as long as we only focus on the life cycle itself, we are missing the critical early planning stage and institutional elements that more accurately typify the responsibilities of the project owner and the project manager. For instance, Morris and Jamieson (2005) study found that in the study phase, project process, practice and people need to be involved in moving ideas to practice at the preplanning phase. Morris and Jamieson stated that when a project’s strategic success is low, the problem possibly lies in the early phases of the project and in the owner perspective. Edkins, Geraldi, Morris and Smith’s (2013) study also concluded that, given the significance of pre-project planning, analysis and evaluation, anything which makes its management more effective should be considered important.

5.4 Impacts of Scope of Work and Scope Creep

In this study of the two mega-projects it was found that there were many technical and non-technical difficulties causing scope creep and change orders; these included poor quality project definition, lack of data accuracy concerning ore quantity and quality at the pre-project phase and conception phases, lack of accurate calculation of ore quality and quantity, owner intervention in decision making, lack of mining expertise and mining engineers, lack of an internal project management team, inappropriate contract strategy, inappropriate contract award mechanism, lengthy traditional procurement system, imposition of unqualified contractors and subcontractors on the company by the owner, lack of knowledge of local market of mining contractors, subcontractors and fabricators (design, construction, logistics and procurement). The director of mega-project execution in the gold company stated that the major cause of scope creep or scope change had been the owner. Interviewee 10, the representative of the owner in the department of finance for the aluminum project, also stated that the owner had caused the project scope creep many times from the beginning of the project and at the construction phase in order to increase the project capacity. Assaf, Al-Hejji (2005) found likewise that project owners in Saudi projects and project planning were the major cause of large project delays. Narayan (2010) found similarly that, with each scope-change, precious project resources were diverted to activities that had not been identified in the original project scope, leading to pressure on the project schedule and budget. Also like the Narayan study, the higher management interviewees stated that type of contract, clauses, insurance, agreement, market change, project team, contractor, insurance, governor law, attribution rule, location, weather and quality of technology at the conception and prefeasibility phases had all contributed to mega-project delay and the scope creep. Similar to the Singh study (2010) a faulty contract management system was the major reason for project delay and cost overrun.

The lack of experience of the project management firm ‘contractor’ led to poor data gathering, a poor communication plan and ambiguity of mega-project processes which in turn led to lack of understanding between all the stakeholders and inter-disciplines and poor documentation, poor project definition, poor scope of work, poor project design in pre-project phase, poor risk management registry, and then possibly to inappropriate allocation of resources and activities. According to Johnsinit (2010), ‘megaproject management needs experience, expertise and exposure (p. 1). Cerpa and Verner (2009) found that project complexity was defined in terms of the different interests of the stakeholders and the reasons for delays were the long communication chain and slow feedback.

The lack of knowledge of the local market led also to incomplete cost estimation in the work breakdown structure, and then to inaccurate design information of the basic design that in turn had led to inaccurate detailed design; as a consequence there had to be rework of project activities starting from the basic design, through to the detailed design stage to the construction phases. In the case of the EPCM contract the situation became more complicated due to lack of internal project management team, lack of owner project control and monitoring.

In fact there were schedule delays at the two design phases and construction phase as well as the pre-project phase (study phase). Thus there were budget blow-outs at different phases of the project. Therefore, scope impact on the project cost and time, and when any scope of change occurs leads to inability to meet the original budget and schedule.

Both subsidiaries' interviewees stated that the procurement contract of the traditional procurement system had caused project delays and had impacted on the course, events and scope of the project. Singh (2009) found, too, that inadequate procurement was considered to be a major reason for project delay and cost overrun.

5.5 Impacts of Contracting and Tendering

The interviewees result shows that the two mega-projects for the gold and the aluminum subsidiaries had faced technical hitches with both types of contracts, the EPCM contract and the EPC contract but more with the EPCM. While the cost of EPC contracts is higher than EPCM, EPC project time is shorter than EPCM and contractor incurs most of project risk (Lampel, 2001). Both subsidiaries agreed that the traditional procurement system had not been effective. Moreover the gold and aluminum subsidiaries agreed that the contract conditions and terms had not been adequate, or as effective as required. Both subsidiaries placed part of the blame for contract glitches on the owner's choice of contractors, the ore data gatherer to pre-project designer, the project manager, then the project designer and finally the project constructor and subcontractors. Higher management interviewees of the company headquarters stated that the type of contract (EPC) clauses, insurance, and agreement had affected the project completion. Aluminum mega-project partner and planner explained that the EPC contract agreement and clauses had not considered some conditions for mechanical completion stage and operation and had affected the project start-up phase. He added that the project owner had inserted a series of difficult contract conditions during the contractor's invitation to bid; these included squeezing contract time, budget, schedule, and unrealistic construction and delivery time. Loots and Henchie (2007) study the risk issues related to EPC and EPCM type of contracts and found that in order to seek competitive tendering, the level of bid and tender packages conditions present by project owner must not neither be too general not too detailed. In the EPCM contract, the owner, Sink (2009) found that the owner can reduce the high cost associated with EPC option although he may incur complicated contractual relationships and possible delays in the schedule. Sink (2009) found, too, that the EPC contract usually uses a fixed price method whereas the EPCM uses the cost reimbursable method. Galloway (2009) stated that different types of contract require different ways to manage them. Berends (2007) stated that the cost reimbursable type of contract is being used by the owners of oil and gas mega-projects for project development phase.

For the aluminum mega-project, the main contractor or ‘technology provider’ withdrew after the completion of the mega-project project development phase ‘preplanning phase’ and this led to additional time, cost and efforts after they shared the expenses; the owner in addition needed to look for another technology provider to join the project and reevaluate the pre-project stage and prepare a new prefeasibility report. Furthermore, due to the consumption of money and time in this stage and to avoid further expenses, the project owner imposed the previous prefeasibility report on the nominated new partner or technology provider with some minor edits for market and material evaluation and this may have affected the project lifecycle due to late engagement of a new technology provider.

The impact of length of contract bidding process may lead, in addition, to delaying invitation to contractors and tenderers at either the initiation phase, the design phase, procurement stage, and construction phase and may in turn lead to delay time of contracting award, and may lead contractors to accepting unrealistic contract conditions with little negotiation when there is increasing market competition, and this could lead to the designer ‘contractor’ speeding up the design and evaluation process to submit the design packages during the time frame in order to avoid contract penalty. This may lead to mega-project design deficiency and rework of some parts of the design which could take time and it may again lead to project delay and project over cost at the basic design stage and then in the detailed design stage and finally in the construction phase when deficiencies have not been corrected at the basic engineering design. These findings are in line with the study of Singh (2010) who found that delay and cost overrun could be inherent in terms of poor contractor selection and unethical behavior, contract bid amount, difference between the winning bid and second bid, difference between the winning bid and the engineer's estimate.

Contract award selection based on low price is often unsuccessful especially for the EPCM type of contract since this type of contract needs a large owner project management team in every single department in order to follow up project activities with the nominated leading contractor; otherwise the contractor will handle all the project activities (project management-design-construction) out with the control of the owner's project management team. Poor selection of contractors due to low bids, with no technical capability to handle the project will lead to cost overruns, schedule delays, poor quality, and a final result that is not acceptable (PMI 2013). Loots and Henchie (2007) found, as in this study, that the owner needed to have a large and experienced in-house team to assist the EPCM contractor as the EPCM contractor could not take full responsibility for completing the project on time and within budget; Loots and Henchie suggested that the EPCM contractor should involve the owner in the making the major decisions thought the project.

The aluminum project director stated that the traditional procurement contract system was not effective due to the conflict of interests and relationships that had affected the final decision-making. The traditional project procurement management including contract management had caused project delays and had impacted on the course, events and scope of the project. The procurement process started after finalizing work break down structure WBS, and determined the mega-project deliverables and suppliers. The impacts could be unrealistic time of item delivery and unclear description of items; unqualified contractor/suppliers may also affect mega-project cost estimation, time, and schedule. Singh (2010) found, too, that an inappropriate and inadequate procurement and faulty contractual management system can cause cost overrun and project delay. Yeo and Ning (2002) found that effective management for procurement system improves the overall performance of the project, especially the project schedule and cost.

The impact of delay of mechanical completion and mega-project start-up occurred in the aluminum project due to the of EPC type of contract in which the clauses and conditions had not considered the risk of failure at the start-up, resulting in delays due to mechanical failure.

In addition acceptance by the contractor of unrealistic contract terms and conditions stated by the owner such as tight deadlines may lead to failure to meet the deadlines. Furthermore, lack of local market knowledge of contractor or consultant (data or ore collector, cost estimators, designer, project manager, and constructor) could lead to consumption of more than anticipated time, effort and funds.

5.6 Impacts of Design

The mega-project design phase starts at the pre-project study or early project planning, not at the basic engineering design in the prefeasibility phase and detailed engineering design in the feasibility phase or project lifecycle process. The length and completion of design phases in the prefeasibility and feasibility phases of the mega projects were considered as a barrier that caused change orders and delayed project schedule. The difficulties that faced the two mega-projects of the gold and aluminum subsidiaries during the design phases were delay in receiving design packages from the designer which, when ready, had been found to be inadequate, and a lack of contribution from owner's design team and owner's value engineering team during the design evaluation process. The gold company results show, moreover, that there had been a delay caused by the higher management in assessing and approving the design assessment (stage-gate process and gate-keeper), poor planning of design bidding and unrealistic conditions placed by the higher management. The aluminum company results show, too, that the operation and maintenance teams had not participated in the design workshops at the preplanning, prefeasibility and feasibility phases. Likewise, Olatunji (2010) found that design coordination, quality of management during design and quality of management during construction impact project delivery time performance. Morris (1997) found that project management had an extremely narrow focus, reflected only in the project life cycle, and ignored the early project planning of design. The impact of delay design packages, and lack of contribution of owner's design team in the design evaluation of the project design and construction supports the findings from interviews conducted by Merrow (2011). Moreover, Youker (1999) found that most projects had design faults at all levels, and no project was without faults. Galloway (2009) found that changing the scope of work during the design stage led to different effects from changes in the construction stage. This study also found that the effects differed between the design and construction stages.

The impacts of pre-planning design transferred to basic engineering and at this stage either the design deficiencies were discovered and re-designed at the expense of time or the design deficiencies were transferred to the next phase, the construction phase, and then the project team discovered the deficiencies late in the project and lost time and money due to repletion of the design deficiency from the basic design. Bordat et al. (2004) cited causes of design errors in most projects to be similar to those found in this study - inadequate field investigation, error in design and specifications, planning errors and design changes.

The design deficiencies started from ore deposit calculation at the pre-planning phase (study phase) and the miscalculations of ore quality and quantity affected the mega-project cost estimation report and resulted in deficiency at basic the engineering design in the prefeasibility phase; the designer and the value management consultant and internal project team failed to find deficiencies; thus the problems moved to detailed engineering design and from there to construction phase and led to project failure. If the three teams had found the deficiencies at the basic design phase then additional project time and cost may not have occurred.

Furthermore, the two mega-project had lack of technical team and technology provider did most of design phases at offshore offices, however at design evaluation stage divided into three levels and at the end of each level the three teams of megaproject (owner, designer and VE consultant) come together to evaluate the HAZOP, yet the design phase reiterated in different occasions and delayed the projects. The impact of certified technical experience in design evaluation, value engineering may contributed to mega-project delay and cost overrun. In addition, implementing project design offshore project design activities including engineering concept, basic design and detailed design, away from owner project management team control including the maintenance and operation teams may resulted in design deficiencies, many change orders, project delay and cost overrun.

5.7 Impacts of Software Programs on Project at Preplanning and Conception Phases

Both mega mining projects entirely depended on consulting mining companies to calculate the quantity and quality of mineral raw materials in the preplanning phase and before the design phases and that had resulted in inaccurate financial reporting, inaccurate cost estimation, design iteration, extra costs for each stage-gate process, and delay in project stages, and also delay in the implementation construction phase. Having full dependency on leading companies to calculate and analyse ore quantity at the preplanning phase and conception phase without a control plan led to poor project cost estimation, and resulted in project delay and difficulties at the design and construction phases. Both mega-projects used a traditional tool to estimate the project cost during the preplanning phase, prefeasibility phase and construction phase, and this use had resulted in several calculation errors appearing clearly after the basic design, detailed design and before and during construction phases for both projects. Moreover, both subsidiaries entirely depended on the main contractor to list and track project procurements during prefeasibility, feasibility and construction phases, and this had resulted in delay of some equipment delivery during the construction phase.

The calculations for this mega project study were inaccurate and affected all phases of the project. Quan, JianHong and Haiyang (2010) study also showed that accurate calculations are vital at the pre-planning stage. They suggested software for data gathering be used at the preplanning phase to find ore quantity and size of open pit including pit design, production and operational management leading to a report encompassing mine resource conditions, mining technical conditions, mineral sales prices, ore mining and processing costs for maximizing the economic benefit. Radulescu and Radulescu (2012) found that the mining companies, even large ones, are investing little in the computerization of the mining activity and one way of increasing profitability would be through widespread computerization of the activity. Azhar et al. (2008) found that in engineering and construction projects inadequate site investigations can increase cost overruns.

5.8 Alignment of Research Objectives with Findings

The following table aligns the research objectives with the problems and findings.

Table 5.1: Align objectives with the findings

Problem	Need	Key literature variables (cross-ref of own sub-chapter) – Ch2	Interview questions – Ch4	Research objectives – Ch3	Methodology - Ch3	Results and Findings - Ch4	Research Questions - Ch5	The key findings Ch7	Conclusion	Deliverable Recommendation explicit section
-Mega-Project cost overrun, delay of time during the preplanning phase, construction phase, and start-up phase. Moreover mega-project quality issues for small and medium companies that intend to build high quality mega-projects. -Many project management professionals, practitioners in the field of industry, academia and developers of software engineering tools have lack the holistic view and understanding of mega-projects project process starting from preplanning phase.	-To assess, clarify and evaluate mega-projects processes especially at the preplanning phase and at the board members, executive level and even at project management team level. -Practical rationalities and practices of the (mega) project delivery during project lifecycle starting from preplanning phase till the delivery phase.	Ch2	Section 4.2 Interviewee question and response.	0. To better mega-project engineering-management processes through analysis of a pre-planning phase evaluation for construction/mining endeavours. This particular research was designed to evaluate the project management processes used in two mega-projects in Saudi Arabia in order to devise an improved project management process framework for the mega-project preplanning, initiation, prefeasibility, feasibility, and construction, delivery and start-up phases.	Qualitative-semi structure face to face interview.	Many difficulties had been experienced during the project phases especially at the conception and prefeasibility phases and had affected the construction activities and these difficulties had led to delays. There was agreement among headquarters, the gold subsidiary and aluminium subsidiary that difficulties had included a lack of understanding of the mega-project processes and the scope at the early stages of the project until the end of the prefeasibility phase, unstoppable extra costs of the technical and nontechnical scope creep and change orders, a lack of definition ,understanding and categorizing of stage-gate deliverables for mining projects, a lack of technical expertise in the mining field, inappropriate internal project management team roles and responsibilities for the mining field, absence of value management engineers and mining engineers, poor project definition and	1- Is there a relationship between project management process, scope creep, value management, contractual arrangement, procurement and software programs generally in terms of speed up project delivery? 2- Are traditional project management process adequately addressing the key variables of “scope” as applied to mega-project? 3- Can current stage-gate project management practices and activities be structured objectively for more efficient realization of mining mega-project briefs? 4- Are any of the constituents of antecedents of stage-gate project management applied in the medium and small scale companies, albeit under the guise of more traditional approaches? 5- Can stage-gate project management	1- Lack of mining expertise and knowledge and lack of coordination of project management teams particularly at the preplanning phase affected the outcomes of the mega-projects, e.g. mechanical failures. It was also found that shareholders had imposed the hiring of the main contracting companies even though they lacked local market knowledge. Moreover the project lifecycle process was hindered by inaccurate calculations of the quantity and quality of the mineral resources at the preplanning phase. 2- Mega-project scope change and change orders contributed to project delay and occurred for many reasons: inaccurate data collection for mineral resources; traditional procurement system which	Cost and time increased beyond schedule during the preplanning, the conception, the prefeasibility, the feasibility and the construction phases and affected the output of each stage by using frequent change orders and iterations of activities and tasks starting with basic design, then detailed design, until the end of the construction phase and beginning of start-up. Details of the impacts, as stated by the interviewees, and further possible impacts are found in the following sections.	In order to overcome many of the highlighted difficulties, the outcome of this research study was the development of a mega-project road map and hybrid process for future preplanning phases Figure 6.9: Roadmap for Mega project development process (Preplanning phase). It includes Mega-project preplanning activities and tasks. -Project process, practice and people need to be involved in moving ideas to practice at the preplanning phase

						planning, a lack of higher management cooperation and communication, a lack of cooperation between all of the stakeholders at the design and construction phases, deficiencies in the design packages, lack of an effective communication plan, lack of interface plan, difficulties with contract strategy, clauses and traditional procurement system, lack of job descriptions, lack of cost estimation accuracy due to the inaccurate calculation of ore deposit at the concept phase, lack of procurement tracking program at the construction phase and lack of modern cost estimation program during the feasibility phase and construction phase. In addition, the selection of project site had had a direct and indirect impact on all project costs such as contract price, labour cost, price of materials, transportation, utility price, staff salary and on the final product. Finally, a lack of consistency in the use of technical standards especially during the prefeasibility and feasibility had occurred due to language barriers. The next chapter,	practices and activities be structured objectively for a more efficient realization of mega-project briefs? 6- Identify the characteristics of successful mega integrated project for medium mining operation firm that is rich of natural resource and lack of project management team. 7- Is there a relationship between size of the mega-project and project delay? 8- Can mega-project shorten to less stage-gate phases in order to save money, time and effort during the initial stages of the project?	allowed conflict of interest in the evaluation process; contracts used allowed control by the main contractors rather than the owner; time lapses between pre-planning and execution meant there were market changes; lack of specialized technical personnel in the project team at the pre-planning phase; lack of cooperation from governmental authorities; lengthy time to receive licenses to manage the logistics related to the location; and lack of experience of contractor personnel (even though they were ‘expert’) with advanced technology. 3- Lack of a clearly defined stage gate process led to inaccurate input parameters; inadequate techniques being used; inaccurate resources being planned for; incorrect estimation; tight or incorrect schedules and planning; design inadequacies; replacement of equipment due		

						Chapter Five, discusses the implications of these results.		to rework; delay in replacing items; increased material costs and delayed project construction phase. Lack of stage gate process clarity among stakeholders increased the project's direct and indirect costs and increased iteration of rework at each phase starting from the preplanning phase through the design phases to construction activities and project start-up. Lack of understanding of the stage-gate process increased conflict among departments; delayed the contracting and tendering process; decreased the accuracy of each objective in the prefeasibility and feasibility phases, increased the likelihood of change orders; decreased the accuracy of cost estimation of every stage; led to a poorly developed project start-up plan and mechanical failure at the end of the		

								construction phase. Unclear stage-gate process, i.e. the data provided, misled the cost estimators and project execution team and caused inadequate cost control starting from the prefeasibility phase and increased capital cost of the project as extra loans had to be applied for; the poor cost estimation led to a delay in identifying the cost overrun, thereby reducing the ability to put in place any strategies. This led to technical issues being unidentified for the project design at the prefeasibility phase. This led, too, to a focus only on short term project delivery rather than on a long term business strategy. Additional costs for attracting personnel were incurred; late government permits and licenses led to delays at different stages of the project. All these reasons led to delayed project start-up. Delays in making final decisions led to		

								delays in transitioning the project to the next stage and caused substantial problems at the start-up of the mega-projects. 4- The inaccurate pre-planning phase of the design phases led to serious impacts. The length and completion of the design phase caused change orders and delayed the project schedule; in addition, as the views of some stakeholder teams had not been considered during the design evaluation process, mechanical failure eventuated. The design deficiencies began with the ore deposit calculation at the pre-planning phase and the miscalculations of ore quality and quantity affected the mega-project cost estimation report and resulted in design deficiencies at the prefeasibility and feasibility phases as well as poor start-up. Implementing the project		

								design activities offshore away from the owner's supervision led also to design deficiencies. These findings led to delays in the implementation of the mega-project and increased mega-project costs.		
		Ch2 Sec 2.1, 2.2 -Over-estimation of project benefits and success in positive way by owner/clients and also under-estimating of cost and time strategically at the preplanning phase. -Optimism bias or strategic misrepresentation during the preplanning phase leads to the megaproject cost overrun -Mega-project culture and management, project complexity & design also the daily practice on the level of cooperation between partners Influence design, project outcomes, and project fund	Q5-Q10, Q19, Q23, Q28,Q30 ,Q39,Q44, Q51, Q62 Q58 –Q59 Q65 and Q78	1.Determine the process used in the early stages of the two megaprojects;	Qualitative-semi structure face to face interview.	The aluminium company faced technical and non-technical hurdles when calculating the cost estimation at the conception and construction phases due to the lack of appropriate tools for the cost estimation and due to the reliance on traditional methods and contractors to collect information and to estimate the cost during the conception and construction phases. For the gold company although relying on the expertise of the contractors, it was found that some of the cost estimations at the project early stages had been incorrect. **linguistic diversity and internal culture:** The cultural factors impacting on the project	As above.	As above.	- The road map may contributes to reduce the impact of time and cost on megaproject output of executives, project managers and planners especially at the preplanning phase which will reflect positively on the overall process , cost and time.	1.Hiring technical leadership 2. Raw material availability 3. Utility & infrastructure availability 4. Project Data collection 5. Production, price, partnership & market forecast 6. Logistics & permits requirement 7. Preliminary process options assessment 8. Hiring operation & support teams. 9. Preliminary assessment idea of alternatives. 10. Potential technology & long lead items. (best contractors for high quality) 11. Evaluate Potential negative & positive impacts 12-Project definition, scope, data & solution 13- Identify opportunity & need 14- Scope of Environment, health & safety

		and increase mega-project cost overrun. -The project owner is the main source of Project change order which lead to project overrun and schedule delay.				implementation, according to all of the interviewees, was a lack of communication plan to enable effective communication among the mega-project inter-departmental teams, higher management, contractors and the internal project teams. This had caused project delays. **Leadership and project progress:** Gold: the company had suffered from a lack of effective leadership as shown by the responses with regard to lack of inter-departmental communication, lack of a proper organizational matrix designating structure and responsibilities and job descriptions. The government also had contributed to the delay through slow approval of licenses. Aluminium: serious hurdles that had negatively impacted on the project from the leadership side and had led to increased project costs and delays in the project delivery time. Headquarters:				15- Preliminary business & economic analysis OOM,EVA,IRR 16-Financial study & capital estimation 1 17. Preliminary project stakeholders 18. Value Improvement Practice checklist 1 19. Project critical Key milestones 20- Risk management study 1

						There had been poor project planning, poor project definition, lack of job descriptions and lack of an effective communication plan. Due in part to these difficulties, staff with expertise had left the company, adding to delays.				
		Ch2 Sec 2.3 Overlap and gap between the PMBOK and PRINCE2 for planning phase. Both traditional approaches can be seen in small-sized companies /contactors / subcontractors, medium-sized contactors /subcontractors , and some small / medium sized operation companies. Project management strategy needed in order to manage the project activities especially between those who follow the American standard and those who follow the British standard.	Q15,Q39	**2.**Identify the measures used for the (mega)-projects at the early stages to avoid project life cycle problems and to speed up implementation of project activities without compromising the quality of work and project;	Qualitative-semi structure face to face interview.	There is a big gap between and both traditional approaches can be seen in small-sized companies/contactors/subcontractors, medium-sized contactors/subcontractors, and some small/medium sized operation companies.	As above.	As above.	-The front-end phase of projects including the project definition, as important for ensuring strategic project. -The lack of awareness of mega-project processes starting from the conception phase may result in absence of standards and technical codes that can hinder the interdisciplinary communication among stakeholders and lead to extra cost starting from basic design in the form of iteration or re-design. -Although the international project management companies had their own expert personnel who could plan, supervise and implement the mega-projects, the final decisions in the process,	Roadmap process may contributes to narrow this gap.

									classification of the project activities and moving activities from one phase to another, were in the hands of the owner or the senior management. -The preplanning phase can have impacts on the progress of the project. -The parent company and shareholders imposed different names of leading international companies on the subsidiaries to be considered for the conception phase. -Politics can interfere with business decisions. -There were misunderstandings with regard to mega-project definitions, concepts, processes and they lacked of defining the meaning of mega-project at the pre-evaluation phase and prefeasibility phase, although both the owner that represents the business and non-function side and the main leading project management contractors represents technical side yet mega-project process still an obstacle to	

									decision-makers in project development phase which often extend to three years. From these findings that there was insufficient pre-planning carried out. Lack of knowledge and coordination were two main aspects impeding progress of this study. The two subsidiaries had used the traditional project management process as a mega-project process except in the design phase which had used the stage-gate process, while the leading project management firm, and construction companies had used the stage-gate process, and the pre-study phase had been ignored.	
		Ch2 Sec 2.4 Most international leading firms are using traditional Stage-Gate Process or Front end loading process, and trying to move toward a new fast-track generation of	Q9, Q22, Q46-Q47 and Q78	**3.** Determine the factors impeding the effectiveness of the measures;	Qualitative-semi structure face to face interview.	Both companies faced obstacles with the stage-gate process for the mining field: shortage of technical Ineffective traditional project management process in the mining mega-project 34%	As above.	-The ineffective use of the stage-gate process and activities is likely to consume project management team effort, time and budget because of the intensive meetings and workshops	The two mega-projects of this study had faced obstacles with the stage-gate process at all stages and ineffectiveness of the traditional project management processes in the early preplanning stage, a lack of defining and understanding of	Roadmap chart. -Stage gate review 1 -Stage gate review **2** -Stage gate review **3** -Stage gate review **4**

		Stage-Gate Process, yet there is lack of understanding of the Stage-Gate Process and how it is implemented. Studies show this system can contribute to the success of a project.				Lack of in-house technical mining engineers 33% Lack of project management teams 33% HIGHER MANAGEMENT (BUSINESS UNIT) expertise in the mining field, a lack of internal project management team for the mining field, ineffectiveness of traditional project management processes in the mining mega-projects, unappropriated linking of the stage-gate process to key stage deliverables and some disciplines, absence of value management engineers and mining engineers, delay in design assessment approval decisions, a lack of cooperation among all of the stakeholders, a lack of defining and understanding stage-gate deliverables for mining projects, a lack of cooperation during the design evaluation and approval, a lack of allotted time for design evaluation and finally a lack of cooperation and communication between contractors and the owner project team.		required to reschedule or rework some of the deliverables. -There is a need to link the stage-gate process to the right department and team. -Without a clearly defined process, inadequate or incorrect planning and scheduling are likely to occur because of inaccurate input parameters, inadequate techniques being used, inaccurate resources being planned for, incorrect estimation, tight schedules, and design inadequacies. -Other impacts could be required replacement of equipment due to rework, delay in replacing items, project schedule delay, and increased cost of equipment and finally extra cost for the whole project. -Lack of stage-gate process clarity among stakeholders,	stage-gate deliverables for mining projects, difficulties implementing the stage-gate process for mineral project and process, inappropriate linking of the stage-gate process to key stage deliverables and some disciplines, a lack of higher management cooperation and length of time of approval process and design assessment approval by higher management (gate-keeper), a lack of allotted time for the design evaluation stage after receiving design packages from the designer, a lack of cooperation and communication between contractors (designer-constructer) and the owner's project management team. The stage-gate process had not yet contributed to effective coordination among the various teams. This was possibly because of lack of understanding of the stage gate process for mining projects but this understanding could improve (recommendations	

								departments and contractors at the project development phase and then execution phase could lead to serious risks such as increased project direct and indirect costs starting from preplanning phase then it moves to the basic design phase and detailed design through to construction activities. -The lack of awareness of mega-project processes starting from the conception phase may result in absence of standards and technical codes that can hinder the interdisciplinary communication among stakeholders and lead to extra cost starting from basic design in the form of iteration or re-design. -Lack of understanding of stage-gate processes and deliverables may also mislead cost estimators and	are made in last chapter. The ineffective use of the stage-gate process and activities is likely to consume project management team effort, time and budget because of the intensive meetings and workshops required to reschedule or rework some of the deliverables. Without a clearly defined process, inadequate or incorrect planning and scheduling are likely to occur because of inaccurate input parameters, inadequate techniques being used, inaccurate resources being planned for, incorrect estimation, tight schedules, and design inadequacies. Other impacts could be required replacement of equipment due to rework, delay in replacing items, project schedule delay, and increased cost of equipment and finally extra cost for the whole project. Lack of stage-gate process clarity among stakeholders, departments and contractors at the project	

								cause inadequate cost control starting from the conception and prefeasibility phases and may affect capital cost of the project; poor cost estimation reporting may lead to a delay in identifying the cost overrun, thereby reducing the ability to put in place any remedies. -Unclear understandings of the stage-gate processes at the project development and prefeasibility phases due to lack of expertise of the personnel involved may cause delay of project completion. -Lack of a proper classification schema for the stage-gate process to classify activities under each phase due to lack of technical expertise in the technical field.	development phase and then execution phase could lead to serious risks such as increased project direct and indirect costs starting from preplanning phase then it moves to the basic design phase and detailed design through to construction activities. Unclear stage-gate processes at preplanning and execution phases may also increase conflict among departments, increase iteration of activities or rework at each phase, delay contracting and tendering process, decrease the accuracy of each objective in the prefeasibility and feasibility stage gate stages, increase the likelihood of change orders, decrease accuracy of cost estimation of every stage, lead to poor project start-up plan and possible mechanical failure at the end of the construction phase. Unclear stage-gate process may affect escalating costs of materials and push out material delivery times due to shortage of construction materials and high	

									demand and these can, in turn, result in delay of project start-up, escalating the capital cost. Lack of understanding of stage-gate processes and deliverables may also mislead cost estimators and cause inadequate cost control starting from the conception and prefeasibility phases and may affect capital cost of the project; poor cost estimation reporting may lead to a delay in identifying the cost overrun, thereby reducing the ability to put in place any remedies. Unidentified technical issues for process and plants at the prefeasibility phase could affect design and result in design rework, extra budget and project delay. Unclear understandings of the stage-gate processes at the project development and prefeasibility phases due to lack of expertise of the personnel involved may cause delay of project completion. Unclear understandings could lead also to a focus only on short	

									term project delivery rather than on a long term business strategy, additional costs of attracting personnel and delay in project start-up. A lack of a proper classification schema for the stage-gate process to classify activities under each phase due to, as previously mentioned, lack of technical expertise in the mining field. lack of making a final decision on project development phase; the basic design stage could lead to delays in transitioning the project to the detailed design stage and in turn result in delays in project procurements that require a long delivery time, especially long lead items such as machinery that could cause substantial problems in start-up of the project; the delay in project schedule, especially the construction activities, may be further impacted by rising costs of materials, fabricators, purchases, labours, contract prices, exchange rates; in addition, as	

									mentioned by all the interviewees, there could be impacts from changes in government regulations (labour and licenses) resulting in delayed decision-making in the initial stages of the project.	
		Ch2 Sec 2.5 Scope change is still a major issue in engineering project management, especially when there is no scope change control in the project. Any poor preparation for project scope during the mega-project preplanning phase may lead to scope creep that could cause cost overrun.	Q16-Q19 Q21 and Q72-Q78 Q3, Q4, and Q12-Q13 and Q24	**4.** Determine the personnel's knowledge in relation to technical tasks; **5.** Ascertain the adequacy of training in the process used; **6.** Determine how scope of work, scope change and scope creep were mitigated;	Qualitative-semi structure face to face interview.	Both companies had faced technical and nontechnical hitches with the project scope of work and project change orders caused by: inappropriate contract strategy, contract award mechanism, imposition of unqualified contractors on the company by the owner (the government and higher management) especially the main contractor and some of subcontractors, owner intervention in decision making, lack of data accuracy at the conception phase, lack of mining expertise, lack of internal project management team, lack of mining engineers, poor quality project definition and poor project planning and lack of local mining contractors.	As Above.	There were many technical and non-technical difficulties causing scope creep and change orders; these included poor quality project definition, lack of data accuracy concerning ore quantity and quality at the pre-project phase and conception phases, lack of accurate calculation of ore quality and quantity, owner intervention in decision making, lack of mining expertise and mining engineers, lack of an internal project management team, inappropriate contract strategy, inappropriate contract award mechanism,	There were schedule delays at the two design phases for both companies and construction phases as well as the pre-project phase (study phase). Thus there were budget blow-outs at different phases of the project. Therefore, scope impact on the project cost and time, and when any scope of change occurs leads to inability to meet the original budget and schedule.	Roadmap chart **12-** Project definition, scope, data & solution **14-** Scope of Environment, health & safety **39-** Update project scope

								lengthy traditional procurement system, imposition of unqualified contractors and subcontractors on the company by the owner, lack of knowledge of local market of mining contractors, subcontractors and fabricators (design, construction, logistics and procurement). -type of contract, clauses, insurance, agreement, market change, project team, contractor, insurance, governor law, attribution rule, location, weather and quality of technology at the conception and prefeasibility phases had all contributed to mega-project delay and the scope creep. -The lack of experience of the project management firm ‘contractor’ led to poor data gathering, a poor communication plan and ambiguity of		

								mega-project processes which in turn led to lack of understanding between all the stakeholders and inter-disciplines and poor documentation, poor project definition, poor scope of work, poor project design in pre-project phase, poor risk management registry, and then possibly to inappropriate allocation of resources and activities. -The lack of knowledge of the local market led also to incomplete cost estimation in the work breakdown structure, and then to inaccurate design information of the basic design that in turn had led to inaccurate detailed design; as a consequence there had to be rework of project activities starting from the basic design, through to the detailed design stage to the construction phases.		

		Ch2 Sec 2.6 Megaproject delay and cost overrun had a relationship with the scope of work, scope change and the contract strategy, bidding process and procurement system. Importance of contract strategy for scope of work and success of the project starting from the preplanning phase of the project lifecycle. Contract, cost estimation based on the scope of work and work breakdown structure must be considered carefully at the preplanning phase.	Q20, Q45-Q56 Q8 and Q45 – Q56 Q38-Q68 Q2, Q38-Q67 and Q68 Q48-Q54	**7.** Determine the type and effectiveness of the megaprojects' contracts; **8.** Determine the internal and external factors affecting the effectiveness of the megaprojects' contracts; **9.** Establish the evaluation techniques used on the megaprojects **10.** Determine the internal and external factors affecting the effectiveness of the evaluation techniques; **11.** Establish how risk was assessed and monitored during the pre-planning and construction phases;	Qualitative-semi structure face to face interview.	Both companies had faced difficulties with the contract strategy and clauses. Both the gold and the aluminium companies faced technical hitches with both types of contracts either EPCM or the EPC, but more with the EPCM. Both companies agreed that the traditional procurement system had not been effective. Moreover the gold and aluminium companies agreed that the contract conditions and terms had not been adequate, or as effective as required. Both companies placed part of the blame for contract problems on the owner. **Market condition and external factors:** interviewees, of both companies highlighted uncertainty of market, uncertainty of government cooperation, uncertainty of the labour law and possibility of changing at any time, imposing unqualified contractors on the projects during the conception phase, design and construction, preoccupation of	As Above.	-The two mega-projects had faced technical hitches with both types of contracts, the EPCM contract and the EPC contract but more with the EPCM. -The traditional procurement system for both projects had not been effective. -The contract conditions and terms had not been adequate, or as effective as required for the gold project. -Both subsidiaries placed part of the blame for contract glitches on the owner's choice of contractors, the ore data gatherer to pre-project designer, the project manager, then the project designer and finally the project constructor and subcontractors. -The type of contract (EPC) clauses, insurance, and agreement had affected the project completion.	Both type of contract whether EPC and EPCM have advantages and disadvantage. However contract type and clauses must discussed carefully.	**Roadmap chart:** **4-** Project Data; Geology & mining Data **6-** Logistics & permits requirement **8-** Hiring operation & support teams **10-** Potential technology & long lead items **14-** Scope of Environment, health & safety **15-** Preliminary business & economic analysis OOM,EVA,IRR **16-** Financial study & capital estimation 1 **17-** Preliminary project stakeholders **18-** Value Improvement Practice checklist 1 **20.** Risk management study 1 **22-** Project Flow Diagram **23-** Financial study & capital estimation 2 **24.** risk management study 2 **25-** Conceptual engineering package developed **26-** Applicable Value improvement practice **29-** Best solution for engineering details **30-** Megaproject specification **31-** Logistics & procurement **32-** Total constructability or buildability review

						top companies in field of manufacturing, project management and mining with other project in the region due to local and regional market boom. The main external factors related to the market that had affected the project had been the government regulations and a lack of proper cooperation (e.g. delays in providing licenses), bank loans, product marketing (geographical area, customer type), lacked of construction contractor at the market boom, lacked of marketing experience to sell the products, lacked of expertise in the mining fields. **Location and logistics:** There had been delays in government delivery of project licenses during the early stages of the project, lack of government cooperation, lack of governmental authorities' cooperation, lack of management interface plan, poor communication between the		-The EPC contract agreement and clauses had not considered some conditions for mechanical completion stage and operation and had affected the project 156 Start-up phase. -The project owner had inserted a series of difficult contract conditions during the contractor's invitation to bid; these included squeezing contract time, budget, schedule, and unrealistic construction and delivery time. -The impact of length of contract bidding process may lead, in addition, to delaying invitation to contractors and tenderers at either the initiation phase, the design phase, procurement stage, and construction phase and may in turn lead to delay time of contracting award, and may		33- Operability & maintainability 34-Develop basic engineering package 35- Complete business & economic analysis EVA,IRR 36. Risk management study 3 37- Value Improvement Practice checklist 2 38- Financial study & capital estimation 3 41- Collecting information for construction phase 42- Collecting information for operation & maintenance 43- Completing detailed engineering 45. Risk management study 4

						company, authorities and local community around the project site, and logistical difficulties such as transportation to/from the remote area.		lead contractors to accepting unrealistic contract conditions with little negotiation when there is increasing market competition, and this could lead to the designer 'contractor' speeding up the design and evaluation process to submit the design packages during the time frame in order to avoid contract penalty. This may lead to mega-project design deficiency and rework of some parts of the design which could take time and it may again lead to project delay and project over cost at the basic design stage and then in the detailed design stage and finally in the construction phase when deficiencies have not been corrected at the basic engineering design. -Contract award selection based on low price is often		

								unsuccessful especially for the EPCM type of contract since this type of contract needs a large owner project management team in every single department in order to follow up project activities with the nominated leading contractor; otherwise the contractor will handle all the project activities (project management-design-construction) out with the control of the owner's project management team. -The impact of delay of mechanical completion and mega-project start-up occurred in the aluminium project due to the of EPC type of contract in which the clauses and conditions had not considered the risk of failure at the start-up, resulting in delays due to mechanical failure.		

								-acceptance by the contractor of unrealistic contract terms and conditions stated by the owner such as tight deadlines may lead to failure to meet the deadlines. -Lack of local market knowledge of contractor or consultant (data or ore collector, cost estimators, designer, project manager, and constructor) could lead to consumption of more than anticipated time, effort and funds.		
		Ch2 sec 2.1, 2.2, 2.3	Q30-Q42 Q14,Q69-Q77 Q11,Q14, Q28 and Q69-Q77	**12.** Establish to what extent technology and software were used and how effective they were in all the lifecycle stages; **13.** Evaluate the performance of the design teams from pre-planning through to feasibility stages; **14.** Determine the factors affecting the performance of the design	Qualitative-semi structure face to face interview.	**Design issues:** Both the gold and the aluminium companies agreed that there had been a lack of contribution from an internal design team and value engineering team, and delay in receiving design packages which, when ready, had been found to be inadequate. The gold company results show, moreover, that there had been a delay caused by the higher management in assessing and approving the	As Above.	**Design:** The length and completion of design phases in the prefeasibility and feasibility phases of the mega projects were considered as a barrier that caused change orders and delayed project schedule. The difficulties that faced the two mega-projects of the gold and aluminium subsidiaries during the design phases	Two phases of design process are the success key of any project and must considered carefully. -Software program is the first step to calculate the raw data for any mining project.	Roadmap chart: **4-** Project Data collection **5-**Production, price, partnership & market forecast **29-** Best solution for engineering details **30-** Megaproject specification **31-** Total constructability or buildability review **32-** Operability & maintainability **33-** Develop basic engineering package **34-** Value Improvement Practice checklist 2

			Q69-Q84 Q80-Q84 Design phase, project team, technology software and value management issues.	teams from pre-planning through to feasibility stages; **15.** Determine the function analysis techniques used **16.** Establish which factors impeded the effectiveness of the function analysis.		design assessment, poor design bidding planning and unrealistic conditions placed by the higher management. The aluminium company results show, too, that the operation and maintenance teams had not participated in the design workshops at the prefeasibility and feasibility phases. **Software issues:** The corporation did not use accurate software programs to calculate the quantity of mineral raw materials in the concept phase and before the design phase as a result of the high costs possibly also due to the lack of technicians to run such programs. The company did not use a software program to track project procurements during the construction phases for the same reason. The company had used a traditional tool to estimate the project cost during the prefeasibility phase and construction phase such as cost comparison of the previous projects and equipment.		were delay in receiving design packages from the designer which, when ready, had been found to be inadequate, and a lack of contribution from owner's design team and owner's value engineering team during the design evaluation process. The gold company results show, moreover, that there had been a delay caused by the higher management in assessing and approving the design assessment (stage-gate process and gate-keeper), poor planning of design bidding and unrealistic conditions placed by the higher management. The aluminium company results show, too, that the operation and maintenance teams had not participated in the design workshops at the preplanning, prefeasibility and feasibility phases.		**38-** Collecting information for construction phase **39-** Collecting information for operation & maintenance **40-** Completing detailed engineering **41-** Completing financial specification **42-** Risk management study 4 **43-** Value Improvement Practice checklist 3 **44-** Final Design test or qualification test

						Function analysis: The value engineering workshops had become a hurdle instead of facilitating the project process at the early stages and this had occurred due to a lack of a dedicated value engineering team, a lack of defined the internal project management team roles and responsibilities during the design phase. The gold company engineering team had lacked value management knowledge and experience, and hence the reason for being isolated from the value engineering workshops. For the gold company function analysis had taken place, there had still been inaccurate information passed to the internal project management department. Both the gold and aluminium subsidiaries used similar traditional techniques to analysis project functions and they depend heavily on the contractor and consultant to analysis the project functions. **Project team:**		The impact of delay design packages, and lack of contribution of owner's design team in the design evaluation of the project design and construction. This study also found that the effects differed between the design and construction stages. The impacts of pre-planning design transferred to basic engineering and at this stage either the design deficiencies were discovered and re-designed at the expense of time or the design deficiencies were transferred to the next phase, the construction phase, and then the project team discovered the deficiencies late in the project and lost time and money due to repletion of the design deficiency from the basic design. The design deficiencies started from		

						Both companies had had internal teams who had insufficient technical and non-technical expertise in the mining field.		ore deposit calculation at the pre-planning phase (study phase) and the miscalculations of ore quality and quantity affected the mega-project cost estimation report and resulted in deficiency at basic the engineering design in the prefeasibility phase; the designer and the value management consultant and internal project team failed to find deficiencies; thus the problems moved to detailed engineering design and from there to construction phase and led to project failure. If the three teams had found the deficiencies at the basic design phase then additional project time and cost may not have occurred. The two mega-project had lack of technical team and technology provider did most of design		

								phases at offshore offices, however at design evaluation stage divided into three levels and at the end of each level the three teams of megaproject (owner, designer and VE consultant) come together to evaluate the HAZOP, yet the design phase reiterated in different occasions and delayed the projects. The impact of certified technical experience in design evaluation, value engineering may contributed to mega-project delay and cost overrun. Implementing project design offshore project design activities including engineering concept, basic design and detailed design, away from owner project management team control including the maintenance and operation teams may resulted in design		

								deficiencies, many change orders, project delay and cost overrun. **Software:** Both mega mining projects entirely depended on consulting mining companies to calculate the quantity and quality of mineral raw materials in the preplanning phase and before the design phases and that had resulted in inaccurate financial reporting, inaccurate cost estimation, design iteration, extra costs for each stage-gate process, and delay in project stages, and delay in the implementation construction phase. Having full dependency on leading companies to calculate and analyse ore quantity at the preplanning phase and conception phase without a control plan led to poor project cost estimation, and resulted in project delay and difficulties at the design		

								and construction phases. Both mega-projects used a traditional tool to estimate the project cost during the preplanning phase, prefeasibility phase and construction phase, and this use had resulted in several calculation errors appearing clearly after the basic design, detailed design and before and during construction phases for both projects. Moreover, both subsidiaries entirely depended on the main contractor to list and track project procurements during prefeasibility, feasibility and construction phases, and this had resulted in delay of some equipment delivery during the construction phase. The calculations for this mega project study were inaccurate and affected all phases of the project.		

								Function analysis: - The both companies engineering team had lacked value management knowledge and experience, and hence the reason for being isolated from the value engineering workshops. - The value engineering workshops had become a hurdle instead of facilitating the project process at the early stages and this had occurred due to a lack of a dedicated value engineering team, a lack of defined the internal project management team roles and responsibilities during the design phase.		

5.9 Weaknesses of the Research

This research was an investigation of the process from the early phases of two complex mega engineering projects for the public sector; the process involved many stakeholders (partners, designers, contractors, subcontractors, suppliers, vendors and people) over the course of eight years of preparation and implementation. The aim of this study was to identify and explore mega-project factors of success and process, keys to timeous completion in the field project engineering management and then seek to document and apply a newly developed (hybrid) project management process suitable for large scale mining engineering and construction projects. It is acknowledged that there were several weaknesses in this study:

- The relationship between governmental project, semi-governmental project and international companies' of project at early stages "preplanning" and "conception" phases usually surrounded by discreet and confidentiality;
- The possibility of lack of some data from interviewees arises due to the position and confidentiality;
- Data collection period had consumed cost and time of the interviewer due to the difficulties to conduct personal interview with heads of the companies and senior executives, which is usually fraught with ambiguity. Furthermore, at a number of times and on several occasions, the interviewer had required to reschedule appointments and interview with higher management, CEOs' and executives due to the busy senior executives schedules, and that wasted time and money;
- At the time of collecting data for this research, one of the difficulties that had limited the collection of abundant information was retirement some of the executives, moved some of them to other companies or countries, bankruptcy of

one contractor, and withdrawal of one of the leading international companies and all of its staff from the project at the mid of preplanning phase.

5.10 Strength of the Research

Despite the weaknesses, this study had many strengths, notably:

- Methodology which allowed the researcher to gather differing perspectives on the megaproject preplanning phase and rest of the lifecycle phase.
- Methodology allowed the research to gather ‘rich’ data.
- The selection of interviewees enabled the researcher to gather differing perspectives on the differing phases of the mega projects.
- The methodology enabled comprehensive, in-depth analysis leading to the development of a new hybrid framework.
- Possibility to provide a holistic analysis of the issues in a sound of integrity.
- The two mega projects data had collected for the same company for two different subsidiaries; one for gold subsidiary and other for aluminum subsidiary including the higher management at headquarters.
- The data gathering obtained from different perspectives and departments and included three CEOs, Four VPs, four directors, the rest are managers.
- Data collection also included project partner interviewees.
- Data collected from four different cities, two sites, for the same company.
- The research covered pre-planning, concept and prefeasibility areas of mega-projects that is rarely found anything like it in the literature.
- Six executives out of fifteen answers an online survey, noting that writing comments were used to enhance replies when complexity was explained.
- Some of interview questions were necessarily triangulated namely asked thrice in different ways to ensure answers were consistent and not contradict each other.

- The CEO's of both subsidiaries had asked the interviewees especially the managers to provide all forms of support for the researcher.

5.11 Chapter Conclusion

Preplanning phase is considered as the most important phase before embark the project lifecycle phases and lack of expertise, knowledge and coordination of project management teams and strategy at this phase could effect on the output of mega-project, also imposing leading companies that have lack of local market knowledge by stakeholders for politically motivated could affect project business decisions. Moreover technical and business data collection for project and market such as accurate calculation of the quantity and quality of the mineral resource effect on the project either positively or negatively. Mega-project scope creep contributes to project delay and occurs due to many reasons such as traditional procurement system and evaluation process, type of contract, clauses, insurance, agreement, market change, project teams, contractor, governor law, attribution rule, project location, weather and quality of technology. Lack of a clearly defined stage gate process and understanding lead to inaccurate input parameters, inadequate techniques being used, inaccurate resources being planned for, incorrect cost estimation, tight or incorrect schedules and planning, and design inadequacies, replacement of equipment due to rework, delay in replacing items, increase material costs and delays project construction phase. Lack of stage gate process clarity among stakeholders increase project direct and indirect costs, increase iteration of activities or rework at each phase starting from preplanning phase then it moves to design phases through to construction activities and project start-up. Lack of understanding Stage-Gate Process increase conflict among departments, delay contracting and tendering process, decrease the accuracy of each objective in the prefeasibility and feasibility phases, increase the likelihood of change orders, decrease accuracy of cost estimation of every stage, lead to poor project start-up plan and possible mechanical failure at the end of the construction phase. Unclear stage-gate process mislead cost estimators and cause inadequate cost control starting from the conception and prefeasibility phases and may affect capital cost of the project; poor cost estimation reporting during preplanning phase and construction phase may lead to a delay in identifying the cost overrun, thereby reducing the ability to put in place any remedies. Unclear Stage-Gate Process and Gate keepers review could lead to unidentified technical issues for project design at the prefeasibility phase. Unclear understandings of Stage-Gate Process could lead to a focus only on short term project delivery rather than on a long term business strategy, additional costs of attracting personnel and delay in project start-up. Delay in making final decision on Stage-Gate Process from Gate keepers could lead to delays in transitioning the project to the next stage and could cause substantial problems in start-up of the project and change in government regulations could hinder leadership decision making or Gate keeper decision.

Inaccurate pre-planning phase of design phases could lead to serious impacts. The length and completion of design phase caused change orders and delayed project schedule, also lack of contribution of stakeholder teams during the design evaluation process effect on project output. The design deficiencies for mining projects starts from ore deposit calculation at the pre-planning phase and the miscalculations of ore quality and quantity affected the mega-project cost estimation report and resulted in design deficiency at prefeasibility and feasibility phases. Regarding contracting strategy, implementing project design activities offshore and away from owner control lead to design deficiency.

CHAPTER SIX

6 STUDY OUTCOME: MEGA-PROJECT PREPLANNING PHASE ROAD MAP

6.1 Introduction

A need exists within the medium-sized and small-sized ‘operation’ industry and project management field to improve mega project process efficiency, effectiveness and objectivity especially at the preplanning phase; it is also important that knowledge can be shared in such a way that less experienced managers and engineers can understand and hence take responsibility for work procedures.

The main outcome of this study is the development of a road map for project management preplanning phase for mega-mining projects, specifically for the construction of plants. This megaproject road map is divided into two vertical phases which represent prefeasibility and feasibility phases of project definition, and each vertical phase is divided into horizontal hybrid sub-stages, and each horizontal hybrid sub-stage contains two gate-keepers for the decision maker to review, assess and approve activities and tasks. Before concluding this thesis and presenting recommendations (in chapter 7) information is the benefits, workflow symbols and activities embodied in this newly developed roadmap. The benefits of the megaproject road map developed following the findings of this study (see Figure 6.7) are now presented:

- The roadmap will boost understanding of the mega-project preplanning process phase in the fields of industry and academia;
- The enhanced understandings will lead to shortened preparation time for the implementation phase of a mega project; specifically tasks at each stage should be

finished in a shorter time with high quality and on budget; change orders and scope of works will be minimized.

6.2 Megaproject Procedure Starting from Project Development Phase

This section explains, firstly, the mega-project task and activity steps at the project preplanning phase as shown in Table 6.1 and then secondly step by step road map process starting from defining the roadmap icon, vertical process and horizontal process for both business and work processes. Finally, the Megaproject preplanning road map which is divided into two stages and each stage is divided into different sub-stages; the first stage represents the business process for project development (prefeasibility) and is divided into sub-stages, and the second stage represents execution of preplanning work process (feasibility) and is also divided into sub-stages.

6.3 Mega-Project Preplanning Process Activities and Tasks

Table 6.1 Mega-project preparation and associated tasks and activities at the preplanning phase

Mega-project preplanning activities and tasks:
1- Mega-project data & information. **2- Opportunity and needs.** **3- Positive and negative impacts.** **4- Mega-project benefits:** ▪ Order of Magnitude Estimates (OOM). ▪ Earn value (EV). ▪ Internal Rate of Return (IRR). **5- Technology strategy.** **6- Business strategy:** ▪ Business development. ▪ Review business potential, risk and opportunity. ▪ Investment review. ▪ Resolution for outstanding issues. ▪ Negotiation of funding issues. ▪ Public notification. ▪ Board review and approval procedures. ▪ Commitments. ▪ Project supervision and tracking. ▪ Project evaluation process. **7- Communication and sharing of knowledge and ideas.** **8- Documentation management, tools and control:**

- Form.
- Checklist.
- Chart.
- Drawings and design.
- Risk management.
- Improving practices.
- Action plan.
- Software and communication.
- Economic value added calculation.
- Conceptual engineering.
- Prefeasibility package.
- Basic engineering.
- Feasibility packages.
- Request to tender.
- Constructability templates.
- Procurement templates.
- Logistics templates.
- Operation and maintenance template.
- Project execution plan.
- Detailed engineering.
- Commissioning plan.
- Request for service.
- Certifications.
- The care, custody, and control of the site or battery limits (CCC).
- Agreements and partnership.
- Official documents.

9- Project stakeholders:

- Project team members' integration.
- Define the external stakeholders and requirements.
- Define permits requirements.
- Communication plan.
- Project fund.
- Community development.
- Environmental issues.
- Well-being and benefits for all stakeholders.

10- Project scope.

11- Project key milestone.

12- Project options and alternatives.

13- Business analysis (EVA and IRR).

14- Economic analysis.

15- Capital estimation.

16- Risk management.

- Environment, health and safety risk: identification, preliminary analysis, defined, control strategy for construction, operation and process.
- Environmental issues: identify issues, examine and control.
- ESH risk management strategies and control.
- Climate change: identify issues, examine significant emissions, control emissions and calculate cost.
- Transfer residual risk to operation and maintenance.

- Business risk: identification of high level risk strategies and solutions.
- Tendering risk and supplier risk for major and small/miscellaneous items.
- Project risk: identify show stoppers and quality control plan.
- Engineering and technical risk: identify standard, legislation and statutory requirements.
- Operational risk: identify show stoppers and control plan.
- Energy risk: review options of lifecycle cost.
- Natural resources management: identify resources issue and examination of usage and conservation.
- Community development: identify issues and communicate issues and cost to stakeholders.
- Wellbeing: identify, define and communicate direct and indirect benefits for all stakeholders.
- Industry and market shifts: identify potential market shift, consumer preference issues and technology shift.
- Life cycle product stewardship: identify potential materials, process, recovery, and despoil issues and cost.

17- Prefeasibility study plan.

18- Conceptual engineering packages.

19- Engineering solution:

- Identify requirements.
- Identify alternatives.
- Identify site location and suitability (investigation and inspections).
- Identify hazardous area.

20- Technical solutions:

A- Utility and process:

- ❖ Project process and options.
- ❖ Process test.
- ❖ Process flow diagram and mass balance.
- ❖ Piping and instrumentation control diagram.
- ❖ Functional specification.

B- Mechanical and Piping:

- ❖ Work breakdown structure and scope of work.
- ❖ General arrangement sketches and drawings.
- ❖ Detail drawings for major equipment.
- ❖ Sketch and drawings for piping plan and elevations.
- ❖ Piping isometrics.
- ❖ Tie-in lists.
- ❖ Material take off: quantities, estimation and budget.
- ❖ Major equipment list, sizing and data.
- ❖ Pipe flow calculation for major equipment.
- ❖ Minor equipment list, sizing and data.
- ❖ Equipment specifications.
- ❖ Signage requirements.

C- Civil and structure:

- ❖ Work breakdown structure and scope of work.

- ❖ Civil engineering guidelines sketches and drawings for major equipment.
- ❖ Calculation of foundation sizing and slab thickness.
- ❖ Calculation of mainframe dimensions and major member sizes.
- ❖ Major equipment structural layout guideline: sketches and drawings
- ❖ Structural specific details.
- ❖ Material takeoff: quantity and order magnitude estimate.
- ❖ Geotechnical report and major civil works.
- ❖ Feedback and survey for board members.

D- Electrical:

- ❖ Functional specification: draft and final.
- ❖ Signal line diagrams.
- ❖ Major feeder lines sketches and drawings.
- ❖ Basic engineering for switchboard, MV/LV transformer substations and motor control center (MCC).
- ❖ Equipment lists & sizing.
- ❖ Motor and power lists.
- ❖ Power requirements.
- ❖ Sketches and layout drawings of substations, MCC, cable ladders, Distribution box and HV.
- ❖ Detail drawings.
- ❖ Typical schematics.
- ❖ Material takeoff: quantities and order of magnitude estimate.
- ❖ Cable tray MTO and cable schedule.
- ❖ Maximum demand, load centers and cable sizing calculations.
- ❖ Equipment protection settings: cable fault level selections and earth fault Loop for major circuits and switchboards.
- ❖ Specifications.

E- Instrumentation and control:

- ❖ Work breakdown structure and scope of work.
- ❖ Functional specification: draft and final.
- ❖ Major instruments list: data and selection.
- ❖ Instrument master list in accordance with piping and instrumentation diagram, and piping/instrumentation control diagram.
- ❖ The size of control system required by project or I/O list.
- ❖ Specific details drawings.
- ❖ Cable block diagram.
- ❖ Material takeoff: quantity and order of magnitude estimate.

21- Procurement and logistics.

22- Capital estimate:

- Equipment supply: budget quotation with allowances.
- Major equipment supply.
- Purchasing specifications and quotations.
- Scaffolding.
- Painting.
- Spares: critical, commissioning and capital spares list.
- Commercial conditions: general procurement, subcontracting strategy and contract negotiation.

- Commodities: data and budget quotations.
- Change management and training requirements.
- Contingency allowance.
- Schedule: preliminary project schedule, critical milestones, preliminary WBS and detail ECM schedule.

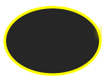
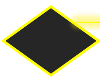
23- Constructability:

- Construction methodology and management plan.
- Work packages for major work and capital estimate.
- Commissioning and start up plan.
- Contractibility detailed review with stakeholders and all contractors for capital estimate.

24- Operability and maintainability.
25- Basic/detailed engineering package.
26- Drawings and scope of work.
27- Procurement packages.
28- Team and training.
29- Functional requirement specification.

Table 6.2 shows the icons used to demonstrate the workflow process for megaproject roadmap.

Table 6.2: Roadmap workflow process icons

	**Beginning and end of sub-stage**
	**Task or activity**
	**Assessment and review previous tasks and activates**

6.3.1 The mega-project roadmap

The roadmap developed from the findings of this study be adopted (see Figure 6.1). Specifically, it is recommended that megaproject process at the preplanning phase be divided into two vertical phases (Figure 6.1), and each vertical phase divided into a horizontal stages which represents pre-feasibility and feasibility (Figure 6.2).

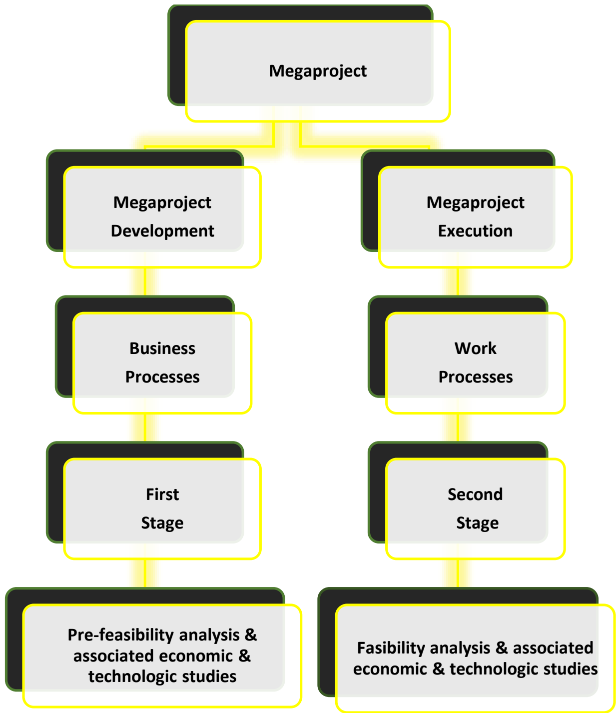


Figure 6.1: Two megaproject vertical phases (Hybrid stage-gate process)

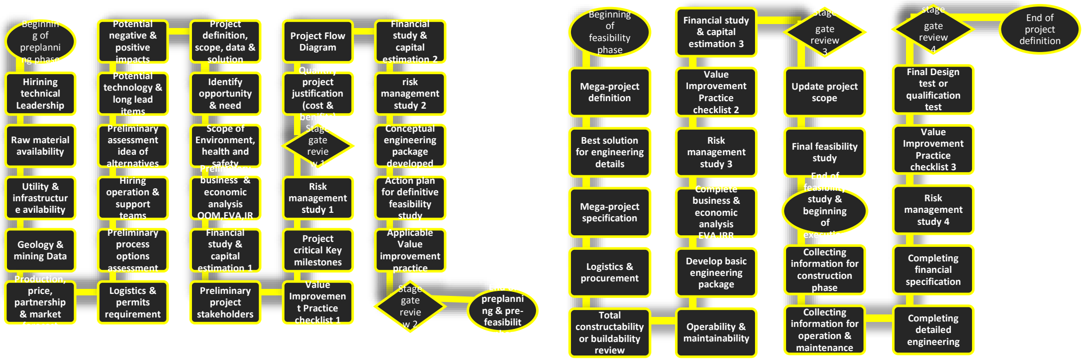


Figure 6.2: Horizontal stages for pre-feasibility and feasibility phases

6.3.2 First vertical phase and first stage

The first phase of the megaproject preplanning phase is a preliminary detailed metric study according to international standards for the first stage of the megaproject business development, the pre-feasibility study (Figure 6.3). This phase assesses business, technology, economy, market and industry and if this phase is feasible economically and technically then a megaproject can move to the next phase which is the feasibility phase execution phase.

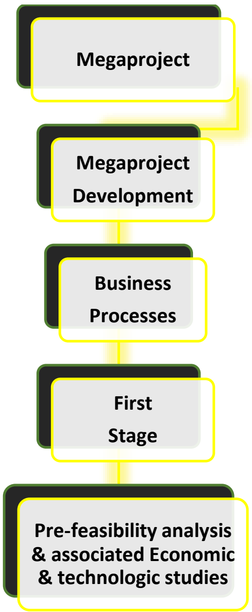


Figure 6.3: First vertical phase and first stage of project definition

6.3.3 Stages of prefeasibility phase

In phase one, stage one (Business process phase), the following stages recommend to be followed as in Figure 6.4:

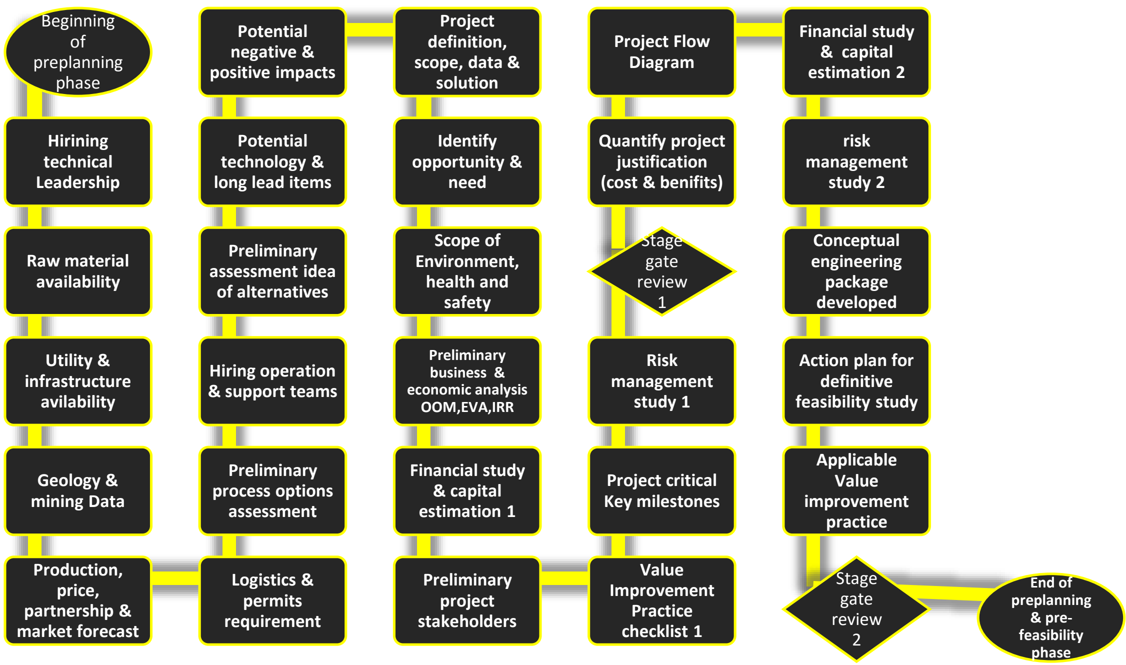


Figure 6.4: Stages of prefeasibility phase (Business process phase)

6.3.4 The business processes

The business process phase (Pre-feasibility study) and the economic and technological associated studies include the following stages:

1- **Beginning of preplanning phase (scratch project preplanning).**

2- Hire technical leadership staff. This should be staff with specialized mining experience.

3- Assess preliminary raw material availability and, in order to do this accurately, a user friendly mining software program needs to be used and current best available mining software programs; this would require budget and a training program e.g. Maptek Vulcan, Leapfrog 3D and GEOVIA Superpac (Radulescu and Radulescu 2012).

4- Assess utility and infrastructure availability. Water and the utilities for the project location must be considered accurately from the pre-planning stage (owner must collect his own data rather than relying on data from others) in order to extract minerals and obtain a loan for the projects; electricity and roads, too, must be considered.

5- Collect geology and mining data. This collection, too, should be done in-house rather than from external consultants in order to ensure accuracy of information.

6- Forecast mineral production, mineral world prices, world market and possible project partnership.

7- Study and prepare project logistics and documentation for project site permits.

8- Assess preliminary process options.

9- Hire support project teams, operation, and maintenance.

10- Assess preliminary idea and alternatives.

11- Determine most appropriate potential technology and long lead equipment which need time for design and fabrication such as heat exchangers, turbines and compressors.

12- Assess the potential negative and positive impacts.

13- Define project scope and assess data and solutions.

14- Determine alternative solutions.

15- Identify opportunity and need.

16- Determine scope of environment, health and safety.

17- Conduct a preliminary business and economic analysis including OOM, EVA and IRR.

18- Carry out a first stage financial study and capital estimation (first stage).

19- Determine preliminary project stakeholders.

20- Develop a first stage value improvement practice checklist (VIP1).

21- Develop project critical key milestones.

22- Conduct a first stage risk management study (RM1).

23- Review and assess the First Stage Gate process (22 points above).

24- Quantify project justification (cost and benefits).

25- Develop project flow diagram (PFD).

26- Carry out a second stage financial study and capital estimation (second stage).

27- Conduct a second stage risk management study (RM2).

28- Develop a conceptual engineering package.

29- Prepare an action plan for definitive feasibility study.

30- Prepare applicable value improvement practice (VIP2).

31- Review and assess the Second Stage Gate process (24-30 points above).

32- End of pre-feasibility phase.

6.3.5 Second vertical phase and second stage

The second phase of the megaproject preplanning phase is a detailed metric study for the second stage of the megaproject work processes to determine whether the megaproject can make a profit before embarking on any financial commitment i.e. a feasibility study is carried out (Figure 6.5).

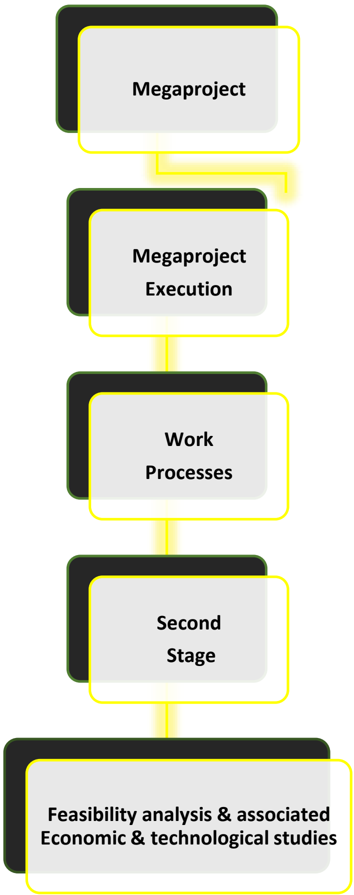


Figure 6.5: Second vertical phase and second stage of project definition

6.3.6 Stages of feasibility phase

In phase two, stage two, the following stages recommended to be followed (Figure 6.6):

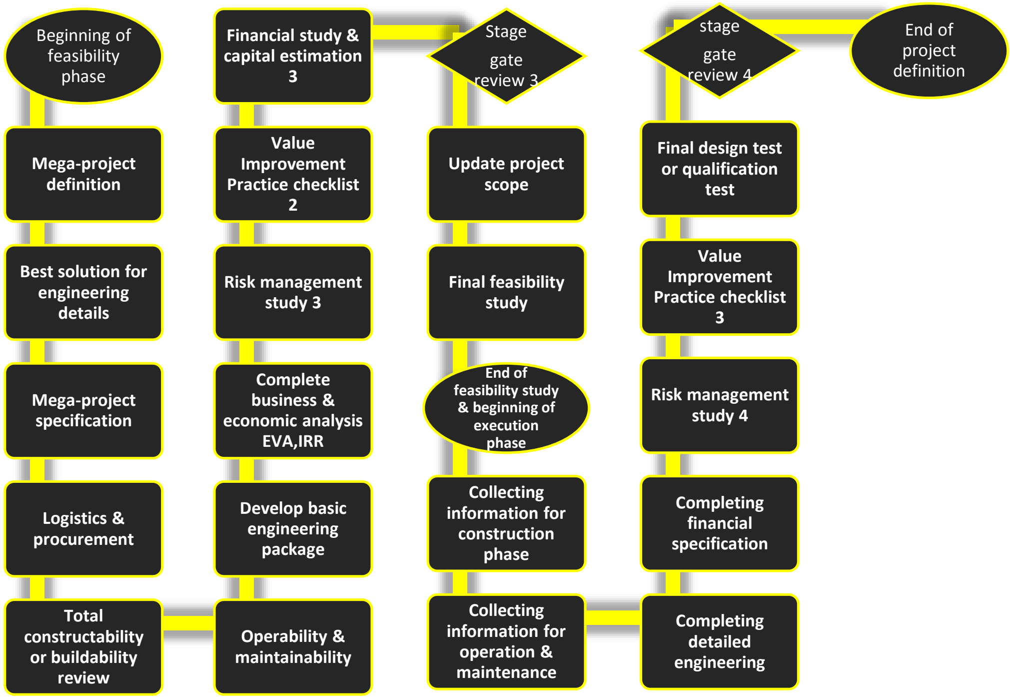


Figure 6.6: Stages of feasibility phase

6.3.7 The work processes

The feasibility study and economic and technological analysis and associated studies include the following stages:

1- **Beginning of feasibility phase.**

2- Define Megaproject.

3- Identify the best solution for engineering details.

4- Prepare megaproject specification.

5- Complete logistics and procurement process.

6- Review total constructability or buildability process.

7- Review operability and maintainability.

8- Develop basic engineering package.

9- Complete business and economic analysis EVA and IRR.

10- Conduct the third stage of risk management study (RM3).

11- Develop the second stage of the value improvement practice checklist (VIP2).

12- Carry out a third stage of the financial study and capital estimation (third stage).

13- Review and assess the Third stage gate process (1-12 points above).

14- Update project scope.

15- Complete feasibility study.

16- End of feasibility study and beginning of execution phase.

17- Collect information for construction phase.

18- Collect information for operation and maintenance.

19- Complete detailed engineering.

20- Complete financial specification.

21- Conduct a fourth stage of the risk management study (RM4).

22- Develop a third stage of the value improvement practice checklist (VIP3).

23- Verify and test the credibility of the overall design and process (qualification test).

24- Review and assess the Fourth Stage Gate Process (17-23 points above).

25- End of project definition.

6.4 Roadmap for Mega project development process (Preplanning phase)

The outcome of this research study was the development of a mega-project road map and hybrid stage-gate process for future preplanning phases (Figure 6.7).

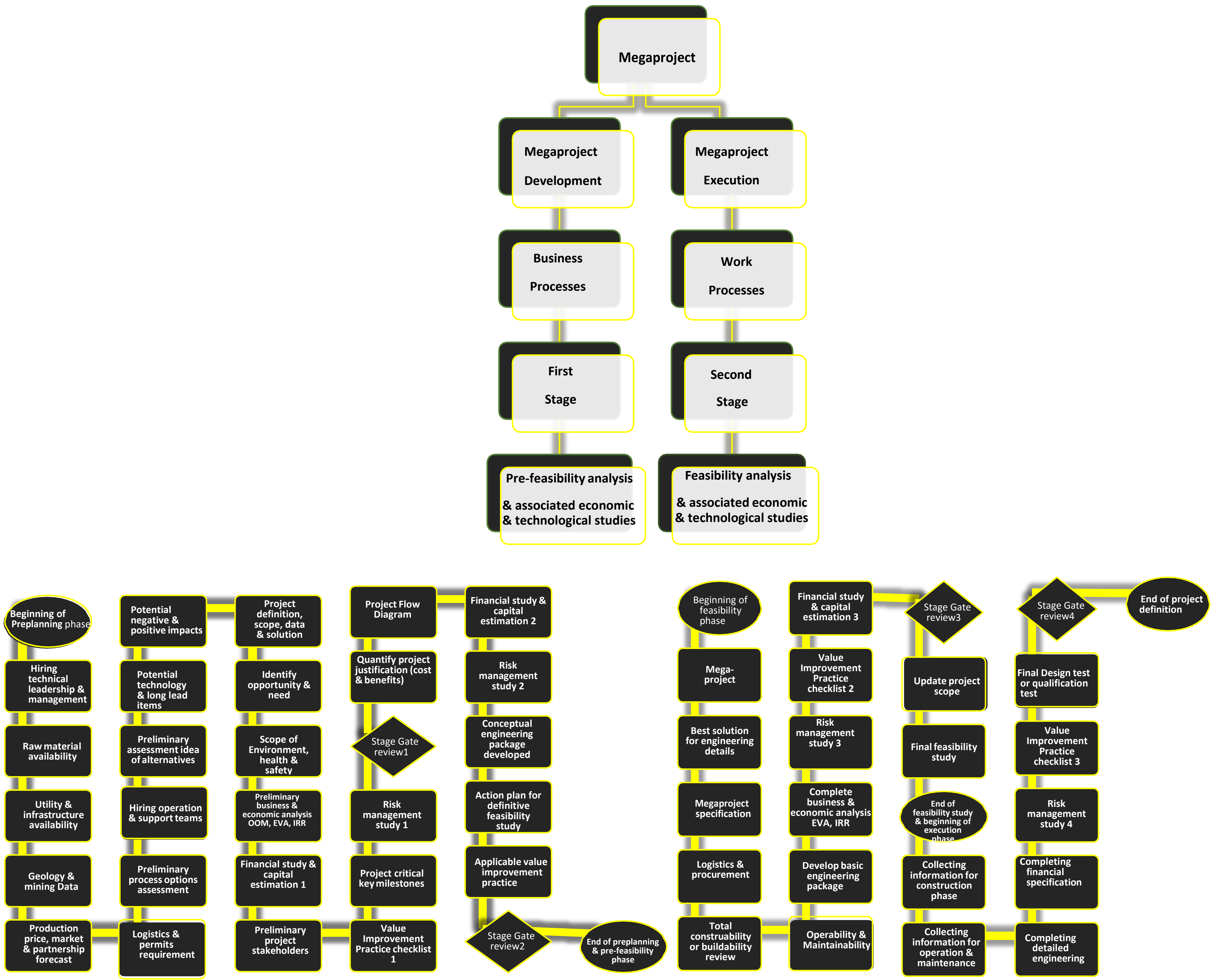


Figure 6.7: Roadmap for Mega project development process (Preplanning phase)

CHAPTER SEVEN

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusions

The research goal of this study was to examine and evaluate the pre-planning process management phase of two mega-projects in an 'operation' company in Saudi Arabia. Primary research was conducted in the form of case studies incorporating semi structured interviews with CEOs, VPs, executives and higher management within this Saudi 'operation' mining company and two subsidiaries. This proved to be appropriate to understand and address the complexities of the mega-project process at the preplanning phase of these megaprojects as the methodology allowed the researcher to collect valuable insights from a range of personnel involved in the mega-projects. These findings were then used to develop a mega-project roadmap and process. The key findings of this research were as follows:

1- Lack of mining expertise and knowledge and lack of coordination of project management teams particularly at the preplanning phase affected the outcomes of the mega-projects, e.g. mechanical failures. It was also found that shareholders had imposed the hiring of the main contracting companies even though they lacked local market knowledge. Moreover the project lifecycle process was hindered by inaccurate calculations of the quantity and quality of the mineral resources at the preplanning phase.

2- Mega-project scope change and change orders contributed to project delay and occurred for many reasons: inaccurate data collection for mineral resources; traditional procurement system which allowed conflict of interest in the evaluation process; contracts used allowed control by the main contractors rather than the owner; time lapses between pre-planning and execution meant there were market changes; lack of specialized technical personnel in the project team at the pre-planning phase; lack of cooperation from governmental authorities; lengthy time to receive licenses to manage the logistics related to the location; and lack of experience of contractor personnel (even though they were 'expert') with advanced technology.

3- Lack of a clearly defined stage gate process led to inaccurate input parameters; inadequate techniques being used; inaccurate resources being planned for; incorrect estimation; tight or incorrect schedules and planning; design inadequacies; replacement of equipment due to rework; delay in replacing items; increased material costs and delayed project construction phase. Lack of stage gate process clarity among stakeholders increased the project's direct and indirect costs and increased iteration of rework at each phase starting from the preplanning phase through the design phases to construction activities and project start-up. Lack of understanding of the stage-gate process increased conflict among departments; delayed the contracting and tendering process; decreased the accuracy of each objective in the prefeasibility and feasibility phases, increased the likelihood of change orders; decreased the accuracy of cost estimation of every stage; led to a poorly developed project start-up plan and mechanical failure at the end of the construction phase.

Unclear stage-gate process, i.e. the data provided, misled the cost estimators and project execution team and caused inadequate cost control starting from the prefeasibility phase and increased capital cost of the project as extra loans had to be applied for; the poor cost estimation led to a delay in identifying the cost overrun, thereby reducing the ability to put in place any strategies. This led to technical issues being unidentified for the project design at the prefeasibility phase. This led, too, to a focus only on short term project delivery rather than on a long term business strategy. Additional costs for attracting personnel were incurred; late government permits and licenses led to delays at different stages of the project. All these reasons led to delayed project start-up. Delays in making final decisions led to delays in transitioning the project to the next stage and caused substantial problems at the start-up of the mega-projects.

4- The inaccurate pre-planning phase of the design phases led to serious impacts. The length and completion of the design phase caused change orders and delayed the project schedule; in addition, as the views of some stakeholder teams had not been considered during the design evaluation process, mechanical failure eventuated. The design deficiencies began with the ore deposit calculation at the pre-planning phase and the miscalculations of ore quality and quantity affected the mega-project cost estimation report and resulted in design deficiencies at the prefeasibility and feasibility phases as well as poor start-up. Implementing the project design activities offshore away from the owner's supervision led also to design deficiencies.

These findings led to delays in the implementation of the mega-project and increased mega-project costs. In order to overcome many of the previously highlighted difficulties, the outcome of this research study was the development of a mega-project road map and hybrid stage-gate process for future preplanning phases (Figure 6.9).

7.2 Recommendations Derived From This Research

The adoption of this roadmap for mega-projects at the preplanning phase will enable shareholders, stakeholders including executives, managers, engineers, and academics as well to make sound decisions based on a better understanding of the mega-project preplanning process, activities and tasks. This will, in turn, lead to reduction of scope changes, and timely deliverance of the project within budget.

In order to facilitate the adoption of the above stages, the following recommendations are provided:

- It is recommended that an induction program be implemented to explain and discuss the roadmap stages;

For the best possible results for medium-sized operation companies and future projects, and before embarking on the pre-planning phase the company leadership and management needs an induction program to explain the roadmap steps to highlight the importance of each stage generally and the possible outcome of each stage for stakeholders and shareholders in order to avoid scope change during the project lifecycle. Each head of technical and non-technical department within the organization can explain the roadmap process and position and role of the department and individuals on the roadmap in order to give each individual a general perception about the mega-project, what and how the megaproject is to be conducted and implemented; also this would show each individual his/her role during the course of the project, and the potential positive and negative impacts of individuals and departments on the project cost, time and process, and on other disciplines. In addition, the roadmap will clarify what can be expected of individuals and departments. This will lead to greater understanding among shareholders, stakeholders, departments and individuals and may improve communication, enhance cooperation and enthusiasm among the project parties and also may help to minimize the number of change orders and scope creep possibility; this may also lead to mega-project time and budget savings at the early stages and during the project lifecycle in general.

- It is recommended that the owner ensure that all service providers (authorities) have the ability to complete the delivery of all services during and after implementation. This can be done by discussing all project main issues with project site neighbors and preparing a project interface plan.
- It is recommended that design company of the mega-project undertake the basic design at the preplanning phase and then at the prefeasibility phase and the detailed design at the feasibility phase in order to avoid design deficiencies. This will enable continuous design work thus avoiding design deficiencies and consequent changes.
- It is recommended that, in order to ensure greater consistency between design evaluation teams which include owner project management team, designer and value management consultant, the designer and value engineering consultant must provide the owner with 'professional certificates' proving knowledge in the fields of value engineering 'VE', project management professional 'PMP', hazard and operability study 'HAZOP', quantitative risk analysis 'QRA', safety integrity level 'SIL', enterprise architecture 'EA', ergonomics for handover and project quality management before and after procurement. Moreover, the consulting firm must provide the mega-project owner with formal documentation, plan and review of the project plan, expected outcomes before starting consultation, especially for design phases and value engineering reviews. Furthermore, value engineering must include in predesign phase, basic design, detailed design, construction, operation and maintenance.
- It is recommended for public projects that the government establish an integrated governmental body concerned with project management to facilitate and speed up mega-project requirements and agreements among governmental authorities; this

will significantly reduce costs and time of mega-projects, and reduce investor team efforts.

- It is recommended that local standards be updated and that local contractors be made aware of the updated standards.
- It is recommended that the traditional procurement system and awarding process based on low price needs to be reevaluated and updated in order to have a high quality mega-project and to avoid uncertainty of procurement delivery, and also to avoid nepotism and corruption in public projects.

CHAPTER EIGHT

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APPENDIX A

INTERVIEW QUESTIONS

QI	**What is your position?**
QII	**How many years of work experience do you have?**
QIII	**Which sector do you have the most experience in?**
QIV	**What is your company affiliation?**
QV	**Are you client or partner?**
QIV	**Is your company public or privet?**
Q1	**What is the capital investment of your mega-engineering projects?**
Q2	**What is your company type?**
Q3	**Did the Mega project have a clear theoretical base?**
Q4	**Did the Mega project have a clear professional image?**
Q5	**How do you define the Mega project?**
Q6	**Was the Mega-project driven by practice only?**

Q7	**Which process did your company follow in the early stages of the project?**
Q8	**Types of mega-project contract at the early stages of the project?**
Q9	**Type of project delivery?**
Q10	**Had you ever faced difficulties to execute Megaprojects in the initiation phase?**
Q11	**Had you ever faced difficulties during detailed design engineering?**
Q12	**How many times did you change the scope of work?**
Q13	**How do you evaluate the scope and the scope creep?**
Q14	**What is the percentage of allocation for front end engineering, design and planning from overall capital cost?**
Q15	**What measures did mega- project at early stages need to take to improve project performance and avoid project life cycle problem?**
Q16	**How did you rate internal lack of awareness or knowledge about this mining project?**
Q17	**How did you evaluate the support from parties with authorities?**
Q18	**How did you evaluate the importance of the technical understanding?**
Q19	**How did you evaluate the importance of the senior management commitment?**

Q20	**How did you evaluate the importance of time to execute the project?**
Q21	**How did you evaluate the importance of the training in organization?**
Q22	**What factors had affected the success of the projects?**
Q23	**How did you evaluate the communication among project stakeholders?**
Q24	**How did you stop project creep from the beginning of the initiation phase and planning phase?**
Q25	**Did this project completely achieve the required objectives in the initiation and planning phase?**
Q26	**How far were you satisfied with implementing projects?**
Q27	**What did you think the main on-going costs are for any given project?**
Q28	**How closely did the project adhere to schedule duration of design, planning study in early stages?**
Q29	**Do you think the funding mechanism for the newly constructed mega project was effective?**
Q30	**Did your organization use tools at the early stages before of project planning? If so, what were they?**
Q31	**What were the main barriers that hinder software tools in mega-projects?**

Q32	**How could these impediments be overcome?**
Q33	**Did you use building information modelling in the concept/initiation/planning phase?**
Q34	**What were the reasons behind the limited use of software tools during early stages?**
Q35	**How did you evaluate the cost of megaproject software?**
Q36	**What were the weaknesses and strengths of the software tools approach in the initiation phase?**
Q37	**How did the external team influence software tools use in this project?**
Q38	**Did you use value management in your organization? If so, how did you use it?**
Q39	**Did your organization use value management during the concept stage of project life cycle?**
Q40	**Did you use value management for design stage?**
Q41	**Did you spend money on value management, software tools during the project early stages? Was it cost effective?**
Q42	**Did your company utilize any economic evaluation techniques as part of the decision process?**
Q43	**How did you rate the flexibility in contractual provisions?**

Q44	**How did your organization make decisions on building a new project?**
Q45	**What was the normal procedure for contract awards in your firm with regards to existing construction project?**
Q46	**What were the main factors (criteria) that play a major role in awarding a contract for a new construction project?**
Q47	**What were the main factors (criteria) that play a major role in awarding of a contract for maintenance of an existing construction project?**
Q48	**Was the current contract award mechanism in your company effective?**
Q49	**How can the contractor inputs be included in the design?**
Q50	**How did you evaluate the traditional procurement system (Design-Bid-Build)?**
Q51	**How can any conflict of interests among project stakeholders be solved?**
Q52	**How did you assess the risk in your projects?**
Q53	**What kind of procurement systems tools did you use? How?**
Q54	**What were the benefits and drawbacks of implementing technology within the current procurement system? How can it be improved?**
Q55	**What type of contracts was used for the megaproject?**

Q56	**What was the normal procedure for the contract award with regards to a new construction project?**
Q57	**How important did you rate time requirement?**
Q58	**Could you evaluate type of accuracy and reliability of cost estimation?**
Q59	**Could you evaluate the type of cost estimation technique used?**
Q60	**Could you evaluate the quality assessment system?**
Q61	**Could you evaluate availability and supplies of resources?**
Q62	**Could you evaluate the government regulation?**
Q63	**Could you evaluate political situation?**
Q64	**Could you evaluate the number of competitor on the market?**
Q65	**Could you evaluate culture impact?**
Q66	**Could you rate weather condition?**
Q67	**Could you evaluate the project location?**
Q68	**Could you evaluate the project duration?**

Q69	Who was your project team leader?
Q70	Who, generally, was responsible for carrying out the project during conceptual/initiation and planning phases?
Q71	Who, generally, was responsible for conducting design changes in the initiation phase and prefeasibility phase?
Q72	What size was your project management team?
Q73	Could you evaluate the number of team members?
Q74	Did you employ an external team to carry out the project prefeasibility study and planning? If so, why?
Q75	How did you evaluate the importance of the teamwork?
Q76	How was the design team briefed?
Q77	What was the appropriate team to conduct design change? Why?
Q78	How did you evaluate the cultural and operating factors among the various regions?
Q79	What methods did you use to carry out the project during the conceptual and prefeasibility phases?
Q80	What percentage of time did you spend on function analysis during the early stages?

Q81	**What did you do for the cases for which you did not use function analysis?**
Q82	**How did you select functions for the project?**
Q83	**Which function analysis techniques did you use?**
Q84	**Which function analysis technique did you use in the evaluation stage to compare alternatives?**

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