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A Framework for Implementation of IPD Principles in Oil & Gas Projects

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Abstract

Investment in the global Oil and Gas sector is huge. In 2014, the cumulative investment in between 2014 and 2035 was estimated to be US$22.4 trillion, equivalent to an average annual spend of more than US$1 trillion. A high percentage of Oil & Gas projects go over budget, however, because of poor performance and major schedule delays. Many of these can be traced to problems originating in the design phase. This phase is typically carried out by experienced design consultants, followed by tendering and then execution, involving large construction organisations.

Project delivery methods in the sector vary, with 57% using Design-Bid-Build, 38% Design-Build, and 5% Construction Manager at Risk. These methods provide no clear integration or collaborative approaches to ensure stakeholders involvement early during the design phase. This research examines the potential for using Integrated Project Delivery (IPD) as a new approach to improve collaboration by engaging full project teams from early in the design phase. It addresses the following questions: How do current practices in the Oil & Gas sector influence project performance? What are the factors behind poor project performance, and how can project performance be improved by the implementation of IPD?

The aim of this research is to create a conceptual framework to implement IPD principles in Oil & Gas projects as a way of improving their performance. This framework will help project stakeholders to be involved during the design phase, which in turn will help to deliver high quality projects, where schedule and costs are tightly controlled. An extensive literature review found 1,056 factors affecting performance, of which 85 could be resolved if addressed at the design phase. A total of 55 factors were related to communication, project management, planning and design problems. A conceptual framework was created to equip stakeholders with a tool to implement IPD effectively. This framework was validated using case studies of very large Oil & Gas projects. This confirmed the criticality of the factors identified, and that they occurred during particular project stages.

The framework was structured by plotting the major project stakeholders on one side and the project phases on the other (design phase, tendering, and construction), followed by the performance factors related to project management, planning, design and communication. For each factor, the stakeholders responsible were identified.

The research concluded that the Oil & Gas industry suffers from poor performance and the current practices and execution strategies are influencing project delivery. There is a clear gap between the design and construction phases. The conceptual framework developed here will help to improve project performance by bridging the gap and involving all the stakeholders during the design phase, making sure that all the identified poor performance factors can be managed by all those affected, at the most suitable time. The framework is also expected to resolve other factors related to resources, procurement, environment and contracting which are linked to design, planning and project management factors.

Chapter 1. INTRODUCTION

1.1 Introduction

In the BP Statistical Review of World Energy, June 2014, it was stated that consumption and production had increased for oil & natural gas to record levels across the globe. It was also stated that world oil consumption had increased by 9.96% and production by 7.1% since 2004 (BP, 2014). Some investments in countries' Oil & Gas industry are considerably higher than their GDP. For example, nearly $100 billion of investments in megaprojects are planned for Mozambique – more than four times its total GDP. Similarly, hydrocarbon companies have been ramping up spending to meet capital requirements. Developing economies are striving to dominate global energy supply, accounting for 80% of growth last year and nearly 100% of growth over the past decade (BP, 2014). The International Energy Agency (IEA) in its 2014 outlook estimates a cumulative investment of US$22.4 trillion in the global Oil & Gas sector between 2014 and 2035.

At the project level, 89% of all Oil & Gas projects overshoot their original budget in the Middle East, 68% in Asia Pacific and 67% in Africa (EY, 2014). These figures are directly in proportion to projects that have schedule delays; for example, 87% in the Middle East, 82% in Africa and 80% in Asia Pacific. In relation to the size of cost overruns and scheduled delays, it was highlighted that 65% of the projects analysed were facing cost overruns, with an average escalation of 23% of the approved budget (IPA, 2011 industry study). In several papers, it has been highlighted that typical Oil & Gas megaprojects are very expensive and often run considerably behind their delivery schedule (Merrow, 2012). Such projects are therefore late to produce revenues and compensate for losses. One of the major field development projects to produce 300,000 BPD of oil in the Middle East lost 30,000,000 USD of daily revenue for nine months due to delays in completion (i.e. 8.1 billion USD at an oil price of 100 USD per barrel) (ADCO, 2013). Another example is a gas condensate project with a total investment of 1.5 billion USD, which made the same again (1.5 Billion USD) in its first six months of operation

(Oil & Gas Magazine, 2000); this shows how important project schedules and timely delivery are.

In the construction related to Oil and GAS industry, the statistics indicate that productivity has decreased since 1964, while all other non-farm industries have increased by almost 200% (US Bureau of Labor Statistics, 2002). Construction’s lack of software interoperability costs the industry almost $16 billion annually (National Institute of Standards and Technology [NIST], 2004). Worldwide, it has been indicated that 40-50% of all construction projects are behind schedule (CMAA, 2005), and one of the biggest costs impacting such projects are inefficiencies built into project execution rather than the costs of raw materials like steel and concrete, or the cost of labour. Owners stated that they felt their project controls were unsatisfactory, quoting project management teams and cost controls as the most critical component requiring improvement (CMAA, 2005). Many factors are repeated and frequently cited by research which lead to project poor performance.

Several studies and research have been conducted within the construction to identify the factors of delays, which have been predicted as: time overrun, cost overrun, dispute, arbitration, total abandonment and litigation (Aibinu & Jagboro, 2002). Delivery delays and cost overruns cause loss of wealth, time and capacity, which translate into income losses and facilities being unavailable for owners. Money is lost through extra spending on equipment, materials and hiring labour as well as loss of time for the contractor (Haseeb, Xinhai-Lu, Bibi, Maloof-ud-Dyian, & Rabbani, 2011), these are some of the factors that impacted the project delivery resulted in poor performance.

Research conducted in the past has verified that the project delivery system has a great impact on the project result. Findings from Gaba (2013) indicated that a combination of the design-bid-build (DBB) and design-build (DB) systems is strongly related to high levels of effectiveness (i.e. project success), with the latter also positively related to quality outcomes of construction projects (Gaba, 2013). As an example, of the 351 projects used for the study by Mark Konchar, the DB project delivery system was delivered 33.5% faster and 6.1% cheaper than the DBB method (Konchar, 1999). Project execution strategy and delivery systems have influence on project performance in the Oil & Gas Industry.

Poor project performance or delay can be associated with the typical characteristics of the project delivery methods involved (Gaba, 2013; Konchar, 1999), as well as design errors, improper communication, improper contracts, conflicts and disagreements, delays in decision making and approvals, etc. (Chanmeka, Thomas, Caldas, & Mulva, 2012; Company, 2012; Fallahnejad, 2013; Fayek, Revay, Doug Rowan, & Mousseau, 2006; Long, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Mortaheb, Amini, Younesian, & Soltani, 2013; Orangi, Palaneeswaran, & Wilson, 2011; Salama, Hamid, & Keogh, 2008), poor communication and improper contract are factor behind poor performance of the Oil & Gas Industry.

These factors are identified not only in literature specific to the Oil & Gas industry but are also common in other construction projects (Afshari, Khosravi, Ghorbanali, Borzabadi, & Valipour, 2010; Ahsan & Gunawan, 2010; Al-Khalil & Al-Ghafly, 1999; Al-Momani, 1Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Merrow, 2003; and others). With such consistent failures in adhering to a project performance, schedule and budget in the construction sector, and more specifically in the Oil & Gas sector, both sectors have realized the need to move beyond cutting inefficiencies within the engineering, procurement & construction activities of the project and redefine the basics, such as the use of innovative project delivery models.

The integrated project delivery (IPD) approach was introduced more recently as an approach to resolve and improve performance and productivity. IPD was conceptually introduced as a collaborative arrangement of the major project stakeholders early in the project, and implemented in an environment of “best-for-project thinking” and shared risk and reward (AIA & AGC, 2011). This collaboration of stakeholders’ objectives to define project issues at the outset has helped to identify conflicts, establish performance criteria, minimize waste, increase efficiency, and maximize the scope for limited project budgets with an ultimate goal of creating a project environment that produces a positive outcome for all stakeholders.

The key challenge in the Oil & Gas industry is to control cost and project schedules. Establishing a collaborative approach from the project's early design phase (also referred to as the concept/FEED design phase) is an essential step for Oil & Gas projects to improve schedule and cost impacts, which eventually improves project performance. Introducing the IPD approach can help to resolve and eliminate various poor performance factors; however, it is crucial to understand the principles of the IPD approach and how to introduce it into Oil & Gas projects from the early design stage.

Poor performance, primarily in the form of schedule delays, is widespread in Oil & Gas projects. Such delays lead to other factors, such as cost overruns and poor quality (Chanmeka et al., 2012; Company, 2012; Fallahnejad, 2013; Fayek et al., 2006; Long, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Mortaheb et al., 2013; Orangi et al., 2011; Salama et al., 2008). Schedule delay and cost increase are important result of project poor performance in the Oil & Gas industry.

1.2 Research Problem

Number of studies have been conducted within the construction sector to identify factors behind poor performance. These include time overrun, cost overrun, dispute, arbitration, total abandonment and litigation (Aibinu & Jagboro, 2002). Schedule delays are a key factor behind poor performance and can lead to other factors such as cost overrun and low quality (Chanmeka et al., 2012; Company, 2012; Fallahnejad, 2013; Fayek et al., 2006; Long, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Mortaheb et al., 2013; Orangi et al., 2011; Salama et al., 2008). Projects frequently impacted by time overrun, cost overrun which lead to poor performance.

Despite the detailed processes involved, assurance tools and execution practices are currently used by the Oil & Gas industry to ensure that a project's objectives are aligned throughout all of the execution phases with a traditional execution strategy (design-bid-build); however, the common factors behind poor performance continue to occur.

Oil & Gas projects engage numerous stakeholders in different phases and stages of the project due to the sequential phases, i.e. the design phase is completed by the designing consultant with the client; bidding then starts for construction; the construction contractor commences; the manufacturers then become involved; and finally the end users (operation and maintenance) get involved. This shows the potential for gaps and disconnection between key stakeholders who do not come into contact during the project life cycle. There is no fixed integration method or collaboration approach to safeguard stakeholders' involvement in the various project phases. Although construction contractor, manufacturers and end users may integrate at a very late stage (during the construction and commissioning phase), they miss out on the concept and detail design phases. This late integration and scattered collaboration can lead to various problems such as massive change orders; uncertainty/risk being unduly considered, which can inflate costs; severe delays to project delivery; technical/design deviations and changes; poor quality; commercial claims; and stakeholder dissatisfaction. All of these factors can lead to poor project performance, schedule delays and cost overruns (Chanmeka et al., 2012). All the factors influence the project performance and result in delays and cost overrun.

No definite framework has yet been introduced to integrate and identify the roles and responsibilities of each stakeholder at the beginning of the project life cycle (design). This would help to determine at which stage each party should get involved to eliminate various poor performance factors and reduce schedule delay and cost overrun and ultimately improve project quality and performance (Fayek et al., 2006; Long, 2014). Integrating all the stakeholder as early as possible is one of the key mitigations to be considered by the market.

As described by Howard Ashcraft, IPD works on principles that reflect early engagement of all stakeholders, systems and procedures. This helps to develop clear goals and objectives and keeps projects centred on them (Ashcraft, 2014). The integrated project delivery (IPD) principle is new to the Oil & Gas industry. It facilitates integration and improves problems arising from late involvement or lack of integration between stakeholders through sequential phasing and stage gates. IPD can ultimately reduce production losses for clients.

Poor performance has motivated companies in the Oil & Gas industry to look for better practices, execution strategies and methods in order to minimize cost overrun, meet quality standards and adhere to production schedules. Understanding the current execution strategies and practices used in Oil & Gas projects, alongside identifying and quantifying the factors behind poor performance, could help to develop a framework to implement IPD principles.

1.3 Critical Poor Performance Factors

Earlier studies by various authors have detailed the poor performance factors of Oil & Gas projects. These include project delays such as design changes, design errors, poor communication and procurement delays as well as issues gaining approvals (Orangi et al., 2011). Factors contributing to poor performance are many, literatures have identify them in details.

Some authors have categorized poor performance factors into excusable and non-excusable factors. Not selecting a competent subcontractor, poor management of project changes, a lack of mechanisms for recording and transferring project lessons, delays in material procurement, delays in the awarding of subcontracts, a lack of proper management and controlling of subcontractors, delays in design, and a lack of communication and coordination are all considered non-excusable delay factors with the maximum impact based on the survey (Afshari et al., 2010). Factors related to design quality and management are repeated by literatures.

In another study, common factors were identified from earlier studies and ranked (Majid & McCaffer, 1998). Based on the above, it was concluded that the highest ranked delay factors were delay in design, a lack of communication and coordination between owners and contractors, late delivery of materials and slow mobilization, damaged materials, poor planning, equipment breakdown, unreliable subcontractors, poor quality and inadequate fund allocation.

Edward Merrow (2003) concluded that of the fourteen megaprojects he studied, seven had failed to meet the project performance expectations by a considerable margin. He suggested that using value-improving practices and having a higher level of integration to support front-end loading is the most important factor for project success (Merrow, 2003). Integrating stakeholders early in the projects was addressed in the literatures.

A study of construction projects in the UAE also suggested preparation and approval of drawings, slowness of owners' decision-making processes and inadequate early project planning as the major causes of delay (Faridi & El-Sayegh, 2006). In Libya, improper planning, a lack of effective communication, design errors, shortage of materials and slow decision making were identified to be the major causes of delays in construction projects (Tumi et al., 2009). The schedule of the Iranian gas pipeline project, which has been categorized as an Oil & Gas project as well as a linear project, has been affected by several of the above poor performance factors, including materials issues, unrealistic project duration, client-related materials, land expropriation, change orders and contractor selection methods (Fallahnejad, 2013). Literatures emphasis several factors are repeated y literatures and they can be addressed by the projects.

1.4 Research Questions

The focus of the research is to answer specific Oil & Gas-related questions:

1. What are the current practices and execution strategies used for project delivery and performance in the Oil & Gas industry?
2. What are the factors behind poor performance, to help focus the effort to improve the performance and work practices of Oil & Gas Industry?
3. How can IPD principles be implemented in the Oil & Gas industry?
4. How can project performance in the Oil & Gas industry be improved by implementing a conceptual framework using IPD principles?

1.5 Aims and Objectives

The aim of this study is to create a conceptual framework to implement IPD principles in Oil & Gas projects. This framework will help project stakeholders in the Oil & Gas industry to collaborate and integrate early in the design phase to deliver projects to a high standard, on time and within budget.

The objectives of this study can be summarised as follows:

1. Document Oil & Gas project execution strategies, practices, factors behind the poor performance of Oil & Gas projects and the IPD principles.
2. Analyse the critical factors behind the poor performance of Oil & Gas projects.
3. Compare existing Oil & Gas project practices and delivery (execution) strategies and identify their main challenges.
4. Create a conceptual framework to introduce an IPD approach into Oil & Gas projects.
5. Validate the proposed framework for IPD implementation.
6. Produce recommendations to implement IPD in Oil & Gas projects.

1.6 Research Output

This research will help to answer specific questions related to current practices in the Oil & Gas industry and to set out the factors behind poor performance and a conceptual framework to implement IPD principles in the Oil & Gas industry.

The results and output of this research are expected to:

1. Confirm the current practices and strategies influencing project delivery and poor performance in the Oil & Gas industry.
2. Confirm that poor performance exists in Oil & Gas projects.
3. Identify the factors behind the poor performance of Oil & Gas projects.
4. Encourage the adoption of IPD principles to address the identified factors behind poor performance.
5. Create a conceptual framework to implement IPD principles in the Oil & Gas industry.

6. Implement IPD principles to improve Oil & Gas project performance.

1.7 Scope and Limitations

The scope of this research is limited to midstream and downstream projects in the Oil & Gas industry, i.e. projects related to constructing major pipeline networks, Oil & Gas production fields, gathering systems, power generation plants, midstream plants where sweetening and stabilization are required, gas refineries, petrochemical plants, and storage facilities. Projects related to Oil & Gas exploration and appraisal, such as seismic, drilling and piloting, are not considered in this research since the number of stakeholders is minimal and the value of investment is low compared to mid and downstream projects. Secondary and primary data, which comprise the literature survey and case studies, do not involve any subsurface or drilling projects. The case studies were selected from Oil & Gas downstream projects, which meet the requirements for this research in terms of participant roles during execution, scale, size and schedule.

This research does not cover low value projects, as these are presumed to have fewer stakeholders; the early design will be less complex, with minimal design duration; and the procurement and manufacturing will be small. Even adding to this the construction contractors and subcontractors, the size and number will be small compared to high value projects. Such low- to medium-scale projects are often awarded to construction contractors who have experience handling smaller designing procurement capabilities, which makes these projects more competitive. However, such contractors do not necessarily have experience handling large-scale projects.

The research scope included high value projects where the design duration takes between 12 to 15 months independently, followed by bidding for construction for 6 to 9 months, and then construction for 32 to 54 months. This size of project follows the stage-gate process, where approvals go through various stages and gates to ensure each stage passes its minimum requirements. The number of stakeholder are large, including clients, designing consultants, project management consultants, government bodies, construction contractors, sub-contractors, major manufactures, minor manufactures and third-party consultancies.

All of the factors behind poor performance and current practices have been covered in the literature survey, and have been referenced in appropriate sections of this report. However, this study focuses on those major factors which have a measurable impact on project performance, and which have been presented in many papers and are frequently referred to in the literature. Certain categories of factors were not covered, namely resources, procurement, quality, contracts and environment. These are specific to a region or to a specific project, and therefore not applicable to other projects. The focus was on key categories such as; planning, design, management, and communication.

The scope of the study is not limited to projects in the UAE or the Middle East since the factors studied were recorded in various projects and locations, therefore the research serves all Oil & Gas projects worldwide. This is due to the fact that Oil & Gas projects around the globe are similar in design, execution and financing methods. Although environmental conditions can vary with location, this is dealt with during the design phase and execution. Projects worldwide are designed using international standards and well-known designing consultants, such as Flour (USA), Bechtel (UK) and Technip (France), and are executed by well-known companies. The same is true in terms of the financing, with well-known Oil International Companies supporting Oil & Gas projects around the globe, such as Shell, BP, ExxonMobil and Total. Factors related to environments or government categories were excluded. The scope of the research was also limited to creating a conceptual framework to implement IPD principles. Framework implementation was not considered in this study, and will require further research.

In the next chapter the researcher will focus to review the literatures of IPD to understand its principles and find out the factors behind poor performance, current execution strategies of the O&G industry, what are the differences between them, which factors are frequently repeated and are they involved in the poor performance. Also the research will try to see the general construction sector and compare its poor performance factors with the O&G factors.

Chapter 2. LITERATURE REVIEW

2.1 Introduction

Data can be sourced from both primary and secondary sources. Secondary data are those data collected from literature audio or video documents such as textbooks, journals, archives, annual reports, government published data and films (Saunders et al., 2009; Collis and Hussey 2003). In this section the researcher has collected the data from various sources but mainly University literature, journals, internet and local experiences.

The researcher will focus in this chapter to review the available literature, understand the O&G projects' size, scale and execution strategies, performance of O&G projects, IPD principles, factors behind the poor performance and how these factors affecting the performance.

2.2 Scale, Size & complexity of Oil & Gas Projects

More than $1 600 billion was invested in 2013 to provide the world's consumers with energy; a figure that has more than doubled in real terms since 2000 and a further $130 billion to improve energy efficiency as per IEA. These projects ranged from the extraction of Fossil Fuels to the Construction of Power stations, Wind farms, Solar Installations, Oil refineries, Storage and handling facilities, Pipelines, Tankers and other transportation facilities (IEA, 2014). In its World Energy Investment Outlook 2014, the International Energy Agency (IEA) estimates a cumulative investment of US$22.4t in the global Oil & Gas sector between 2014 and 2035. The IEA expects Oil & Gas spending to increase sharply, increasing by almost 50% from its average of US$678b per year over the 2000–2013 period (IEA, 2014). The scale of investment indicate the advantages of improving the performance of this industry.

The graph shows how the Oil production has increased since 2004 from 81 Million Barrel per day to 86.7 MBPD, this increase reflects the world growth and demand on the oil supply. This demand is reflected on the projects size and number of development required to meet the increase on the production. The same graphic shows how the gas production increased during nine years from 259 Billion Cubic Feet per Day to 353 Billion Cubic Feet per day, this reflect the increase on the industry and shows how this demand will add more projects to the Oil 7 gas market to compensate the shortage and keep the supply to the market.

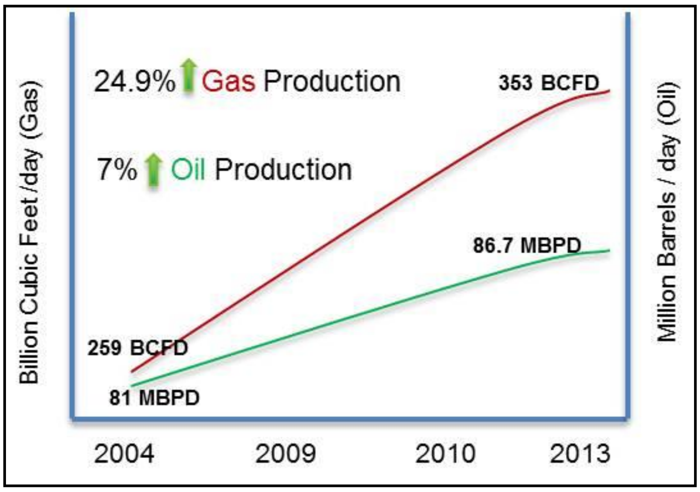


Figure (2.1) World Oil & Gas Production
Source: BP Statistical Review of World Energy

Lukoil in its publication, Global Trends in Oil & Gas Markets to 2025, have estimated based on the increasing population and consumers in Asia will support the Oil demand increase. Apart from this, the weakening dollar, motorization of Asia and increasing cost of exploration and production will support the Oil demand and pricing. (LUKOIL, 2013). Despite substitution of Oil as a primary energy source, Hydrocarbons (Oil & Natural Gas) still constitute about 53% of the global energy production spectrum (IEA, 2014). Deloitte in its publication, Oil & Gas Reality Check, 2015, highlights the reversal of trend on Hydrocarbon product imports by various developed nations. This in turn is pushing Middle Eastern Oil Producing nations to find new consumer markets and more competitive pricing to compete with the reducing rate of oil demand. (Deloitte, 2015). Even IEA estimates only a growth of 0.9 MMbbl/d in Oil and Gas demand in 2015. (IEA, 2015). These dynamics can raise several questions on economics of exploration and production of new fields by the oil producing nations. UAE holds more proven reserves than any other region in the world as per the Middle East well evaluation report issued by SBC. This increases the potential for future developments in the

UAE (SBC, 1997). The figure below shows the proven oil reservoir capacities in different regions of the world.

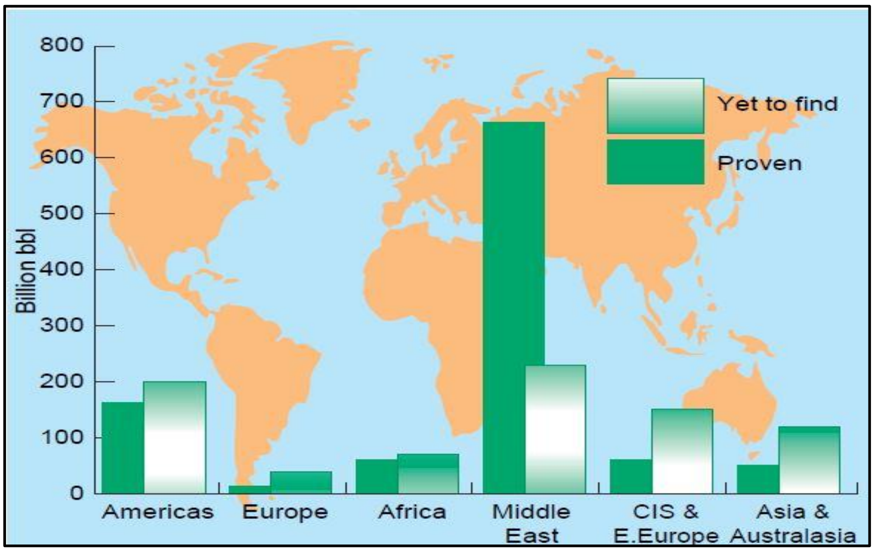


Figure (2.2) Proven Oil Reserves Worldwide
Source: Middle East well evaluation report, SBC, 1997

In an alternate perspective, in its World Energy Investment Outlook 2014, the International Energy Agency (IEA) estimates a cumulative investment of US$22.4t in the global Oil & Gas sector between 2014 and 2035. The IEA expects Oil & Gas spending to increase sharply, increasing by almost 50% from its average of US$678b per year over the 2000–2013 period (IEA, 2014). The number of global oil and gas companies with capital budgets exceeding $1 billion more than tripled to 132 in 2012 from just 40 in 2000, while those with capital expenditures exceeding $5 billion increased fivefold from seven in 2000 to 35 in 2012 (Deloitte, 2013). Various literatures confirm the size of this sector could be the biggest in the market and one of key development sector for some countries.

Figure (2.3) below shows the number of global oil and gas companies with large capital investments.

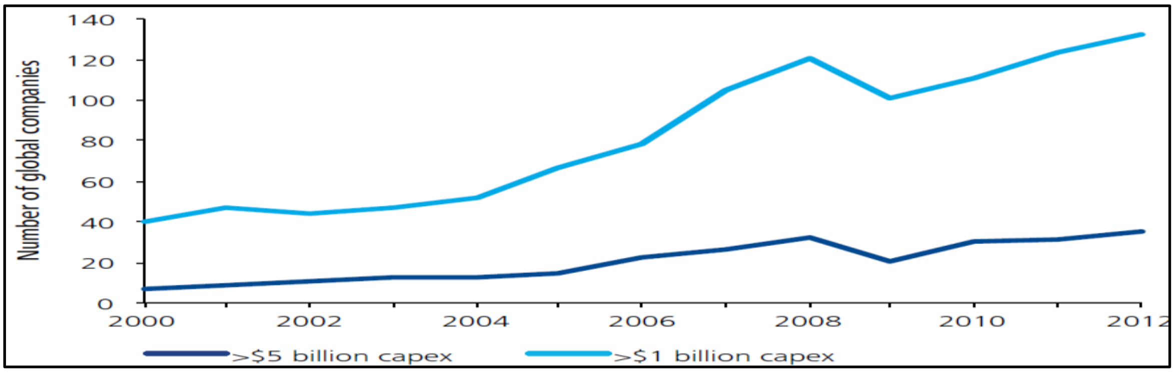


Figure (2.3) Number of global oil and gas companies with large capital investments
Source : (Deloitte, 2013)

As per the research by Schlumberger Business Consulting, the Number of mega Projects (Value above $1 Billion) in Oil & Gas has almost quadrupled in the past 10 years to reach USD 550 Billion (SBC, 2012).

Falling price of Oil and Gas products has been attributed to surprises in production of unconventional Oil, the financial crisis and resulting weakening global demand, appreciation of US Dollar, growing trends of moving towards renewable energy sources lately and international Policies (World Bank, 2015). Relative lower prices of Oil per barrel due to surplus production and lower demand has encouraged in developing more cost efficient methods for developing and sustain the production from fields developed. Figure (2.4) below shows the distribution of proved reserves in 1993, 2003 & 2013.

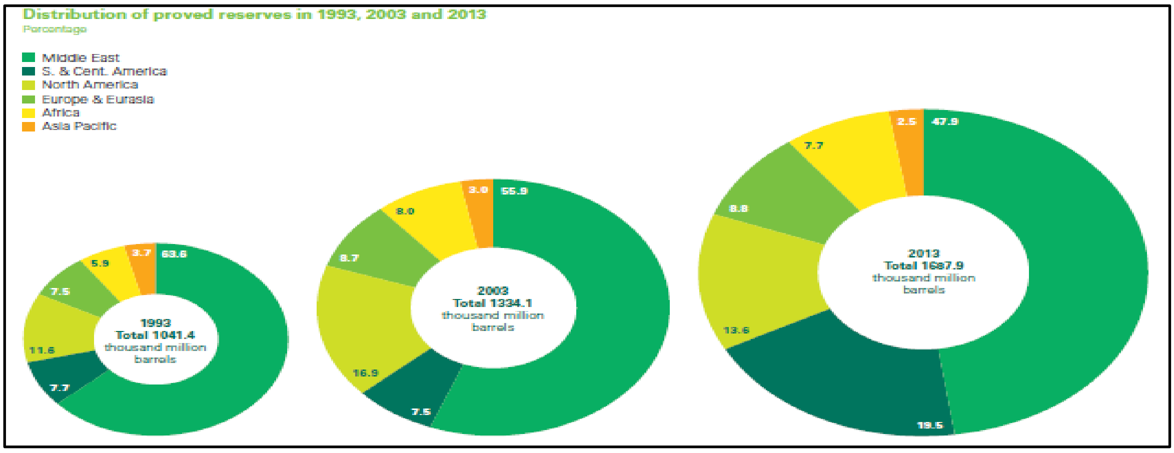


Figure (2.4) Distribution of Proved reserves in 1993, 2003 & 2013
Source : (BP, 2014)

The number of global oil and gas companies with capital budgets exceeding $1 billion more than tripled to 132 in 2012 from just 40 in 2000, while those with capital expenditures exceeding $5 billion increased fivefold from seven in 2000 to 35 in 2012 (Deloitte, 2013). The Number of mega Projects (Value above $1 Billion) in Oil & Gas has almost quadrupled in the past 10 years to reach USD 550 Billion (SBC, 2012). Size of this sector is increasing and any improvement could contribute to the investment values.

2.3 Performance of Oil & Gas Projects

Based on the conclusions drawn from the earlier studies by various authors on the delay factors for projects, the factors were mentioned in this section. Linear projects with repetitive works have been executed with poor performance factors which are commonly noticed in delayed projects such as design changes, design errors, poor communication and procurement delays, issues in approvals, etc. (Orangi et al., 2011). The Iranian gas pipeline project, which has been categorized as an Oil & Gas project as well as a linear project, has several of the above poor performance factors impacting the schedule, including materials issues, unrealistic project duration, client-related materials, land expropriation, change orders & contractor selection methods (Fallahnejad, 2013). Below are some of the projects' factors behind poor performance highlighted by the literatures which were executed in USA, CANADA, IRAN, Australia, Ghana, Malaysia, Korea, Saudi, etc. it is observed that all are typical in their nature, design and execution, and the factors were dominate and behind other factors such as cost overrun and poor quality which all lead to poor performance, since the factors were presence in various regions, therefore they are considered as a global and common Oil & Gas factors, Even though this is not an exhaustive list, the most frequent, high priority and repeated factors highlighted by the authors are mentioned.

The factors related to quality engineering work have been studied in the literature relevant to Iranian Oil & Gas projects and that suggests regular client communication and involvement during the project and timely document approval, engineers' experience, change orders, client interference, good team work and coordination between engineering departments during design, have the highest impact on the schedule (Mortaheb et al., 2013). Design issues and project management are major poor performance contributors by the literatures.

Some authors categorized the poor performance factors as excusable and non-excusable factors. For instance, not selecting a competent subcontractor, poor management of project changes, a lack of mechanism for recording and transferring project lessons, delays in material procurement, delays in the award of subcontracts, a lack of proper management and controlling of subcontractors, delays in design, lack of communication and coordination are all considered non-excusable delay factors with the maximum impact based on the survey (Afshari et al., 2010). In another study, common factors were identified from earlier studies and have been ranked (Majld & McCaffer, 1998). Based on the above, it was concluded that the highest ranked delay factors were; delay in design, lack of communication and coordination between owners & contractors, late delivery of materials & slow mobilization, damaged materials, poor planning, equipment breakdown, unreliable subcontractors, poor quality and inadequate fund allocation.

Research carried out by Mashayekhi presented a dynamic model developed using the concept of system dynamics. Mashayekhi concluded that field studies can identify the causes of delay at project level but a system dynamic approach finds the source causes which are most responsible for delays by taking a global view. It was concluded that the results of the system dynamics approach based on interviews and document reviews is similar to the field study outcomes (Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Literatures have identified factors behind the performance.

Edward Merrow (2003) concluded that of the fourteen mega projects he studied, seven had failed to meet the project performance expectations by a huge margin. He suggested that using value improving practices and having a higher level of integration to support Front-End Loading is the most important factor of project success (Merrow, 2003). Literature emphasis on the integration during the design phase.

Arpamart Chanmeka (2012) presented results from his study on 37 Oil & Gas projects in Alberta. These are considered to be unique Oil & Gas projects in the U.S with respect to the mega size budgets, high overlap of engineering & construction, harsh weather conditions, remote site & labour shortages. The study results showed that projects which could complete a considerable amount of engineering prior to the start of construction could deliver a much better project performance. As per the author, implementation of best project management practices and proper estimation of labour productivity along with considerable engineering completion prior to the start of construction can improve the project outcome (Chanmeka et al., 2012). Literatures address the advantage of complete designs and the completed design value in the project performance.

Mohamed Salama, Moustafa Abd El Hamid and Bill Keogh, in their paper, stated that the factors identified for delay in construction projects may not be applicable for Oil & Gas projects due to the difference in the industries. Their paper studied the Oil & Gas projects specifically in the UAE. The authors related the delays in the construction stage (also referred to as the EPC phase) of a project to the early delays in Front End Engineering Design (FEED). In addition, delays in procurement, material delivery and poor selection of contractors in FEED and EPC Phases have been identified as the major reasons for delay in Oil & Gas projects (Salama et al., 2008). The construction industry data collected from various civil projects in Dubai & Abu Dhabi showed that the major reason for claims arise from changes or variation orders, delay from owners, oral changes from owners and delay in payments by owners (E. K. Zaneldin, 2006). The observation from Oil & Gas projects in the UAE suggests that poor FEED is a cause for major delays. The civil projects in the same region stated that the changes in design and delays from owners was the main cause for claims. It is evident that eliminating the common cause of improper early design can reduce both construction delays and claims.

Another study on the construction projects in the UAE also suggested that preparation and approval of drawings, slowness of the owner’s decision-making process and inadequate early planning of the project are the major causes of delay in UAE construction projects (Faridi & El-Sayegh, 2006). Project management and client involvement have been addressed in several literature and identified them as factors behind project performance.

In a study of Oil & Gas projects in Alberta (Fayek et al., 2006), the authors suggested the following changes to improve project performance; selection of the right scale of project ($200 to $300 million), providing selective overtime to boost labour productivity, skilled & experienced workers and supervision, substantial completion of engineering prior to the start of construction, team integration and communication, setting realistic targets, proven vendors and proper planning.

In a study of process plants and offshore Oil & Gas projects, the major reasons for delay were stated as: insufficiently defined design (FEED), inadequate design basis for production rates, improper contractor cost estimates, ambiguity of contract documents, inadequate documentation, multiple change orders, insufficient management of contractor design and construction interfaces, insufficient and inexperienced owner technical personnel, inadequate baseline schedule, insufficient camp facilities, and inexperienced management team from owners (Long, 2014). Along with incomplete designs factor there are many factors impacted the project performance.

In building construction projects in developing economies, such as Thailand, the major reason for delays were material issues, changes in design & coordination problems (Ogunlana et al., 1996). A study of a ground water project in a similar developing economy, Ghana, stated the causes of delay from a different perspective. According to contractors and consultants, delays in financial payments was the most important reason, whereas according to the owners, poor contractor management was the most important reason for delay in projects (Frimpong et al., 2003). A case study on a road construction project in another developing economy, Zambia, suggested delays in financial payments was the major cause for a delay, very similar to the study conducted in other developing economies (Kaliba et al., 2009). In various literatures project management and client changes were identified as major factors behind the project performance.

In Vietnam, poor site management and supervision, poor project management assistance, financial difficulties of the owner, financial difficulties of the contractor and design changes are the five most frequent, severe and important causes for project delays (Le-Hoai et al., 2008). In the United Kingdom the lack of information, variation orders, ground problems and bad weather were more frequent reasons for project delays whereas overseas it was variation orders, material delays, waiting for information & M&E procurement - in order of importance (Sullivan & Harris, 1986). High rise projects in Indonesia were delayed because of design changes, poor labour productivity, inadequate planning and resource shortages (Kaming et al., 1997). There are factors not related to the design phase however they could be address early in the design to overcome their problems during construction.

A survey of 130 construction projects in Jordan indicated that poor design and owner negligence, change orders, weather conditions, site conditions, late delivery, economic conditions, and increased quantities are the main causes of delay (Al-Momani, 1999). In another study in Jordan the authors considered the contractor's perspective; financial difficulties faced by contractors was the most frequent cause of delays and increased change orders were the second most important factor. Poor planning by contractors was identified as the most important delay cause from the owner's perspective (Sweis et al., 2008). Results from projects in Jordan concluded that owner interference, inadequate contractor experience, financing and payment, labour productivity, slow decision making, improper planning and subcontractors were the main causes of delay (Odeh & Battaineh, 2002). Incomplete designs and poor project management are repeated in several literature and require more focus by the sector to improve.

In Libya, improper planning, lack of effective communication, design errors, shortage of materials and slow decision making were identified to be the major causes of delays in construction projects (Tumi et al., 2009). Planning and communication are related to poor project management and these factors were addressed by the literatures.

When 100 Asian projects sponsored by the Asian Development Bank were studied, the length of contract, procurement, civil works, land acquisition, and consultant recruitment were found to be the main governing delay factors (viz. India, Bangladesh, China & Thailand). Further critical causes of project delays were attributed to natural catastrophes and host country bureaucracy (Ahsan & Gunawan, 2010). Studies from Hong Kong projects suggested that the study on causes of delay is always subject to bias. The root cause analysis may provide more insight to the root problem as compared to the surveys (Kumaraswamy & Chan, 1998). The literature has identified factors related to the client rather than to the design side and they can be addressed early in the project phase.

In the Indian project environment, a lack of commitment, inefficient site management, poor site coordination, improper planning, lack of clarity in project scope, lack of communication and substandard contracts were more predominant reasons for schedule delays (Doloi et al., 2012). It was noticed from the literature factors related to poor project management are repeated in difference locations and countries.

The most common reason for delays in Pakistan are natural disasters like floods and earthquakes, financial and payment problems, improper planning, poor site management and insufficient experience. A shortage of materials and equipment are also cited as common reasons for delay (Haseeb et al., 2011).

Delay causes for utility projects in Saudi Arabia were attributed to cash flow and financial difficulties, delay in work permits and the practice of awarding the contract to the lowest bidder (Al-Khalil & Al-Ghafly, 1999). The outcome of a study in Saudi Arabia suggested change orders are the single most common cause for delay (Assaf & Al-Hejji, 2006). In a similar study on building projects in Saudi Arabia, the financing category of delay was the most important reason for project delays (Assaf et al., 1995). In the Malaysian construction industry, difficulties in financing projects by contractors, conflicts in sub-contractors' schedules during the execution of projects, reworks due to errors during construction and conflicts between contractors and other parties along with other such delays caused by contractors have been identified as non-excusable delay factors (Hamzah et al., 2011). A similar study by Sambasivan, has identified improper planning by contractors, poor site management, inadequate contractor experience, inadequate payments from client, problems with subcontractors, shortage of materials and similar contractor related delay causes (Sambasivan & Soon, 2007). In a similar study in the Malaysian construction projects context, it was concluded that financial problems of the contractor are the major cause of delay followed by poor site management, delays in receiving materials and coordination problems (Alaghbari et al., 2007). The delays in the Malaysian construction industry were also compiled in a technical paper (Chidambaram Ramanathan, 2012). Poor project financing factor was identified by the literature in several projects.

A study of the Korean train express project showed the causes of delay in a phased manner. During project initiation, a lack of technological knowledge and improper geological surveys were major delay reasons. Acquisition of the work site, frequent changes and lack of owners' management skills were also graded as important delay causes (Han et al., 2009). lack of experience of engineers is related to poor project management.

A questions in Egypt suggested that the type of project bidding & award, ineffective planning, variation orders / scope changes, delay in revising and approval of engineering documents were highest rated as per frequency index. On the severity index a shortage of construction material, fluctuations in cost, payments & finance issues are ranked the highest and on importance index finance issues, variation orders / change orders and sub-surface condition effects are rated the highest (Marzouk & El-Rasas, 2014). Building construction projects in Egypt were impacted by financing issues during construction, delays in contractor's payment by owners, design changes by owners or their agent during construction, partial payments during construction and non-utilization of professional construction/ contractual management as per one study (El-Razek et al., 2008). Poor engineering document also related to poor management and incomplete design.

2.4 Summary of Critical Factors Affecting Project Performance

2.4.1. Introduction

The critical factors behind poor performance of projects were expressed in various literature papers and all have emphasized on the commonality of the factors that were faced by all the projects regardless of the geographical locations and nature of the contractors. However, the factors criticality and its magnitude of impact on the poor performances varies from project to project. In all thirty-three (33) critical factors referred and confirmed in various individual literature papers (38 papers referred herein) have been grouped, summarized, tabulated in Table (2.1) and reproduced hereunder.

2.4.2. Poor Project Management

Lack of effective Project Management factor was experienced in several papers; Afshari has mentioned that lack of project management experience were noticed from the client organization, as unqualified management team were engaged and their roles and decision making was poor, that caused delays in approval of key decisions and documents during critical period of the project (Afshari et al., 2010), Ahsan & Gunawan, also discussed Lack of effective Project Management factor was extended to the designing consultant, where the consultant in order to save cost recruited inexperienced management team, where project manager, engineering manager were weak to challenge the client comments and requirements and kept the key engineering points unresolved without proper close out, this affected the design duration and incomplete deliverables were obvious, (Ahsan & Gunawan, 2010). Alaghbari extended the poor management role to address the project management consultant that was awarded by the client, the role of the project management consultant was ineffective during the entire project cycle; i.e. engage in unproductive argument with the designing consultant, delay documents approvals without any conscious efforts to expedite, not taking firm decisions on critical engineering issues, and the consultant could not mobilise the appropriate resources at the right time, this contributed to inaccurate and incomplete technical document submission and increased the recycle of engineering reviews by client, designing team and during the detailed engineering work by the construction contractor (Alaghbari et al., 2007). Al-Momani added that effective and good project management play major role in any project success, and is critical at the early design since key decisions are made early in any major project, the effective project management is not limited to the client side, but it covers designing consultant, project management consultant, construction contractor and the manufacturers project management team (Al-Momani, 1999). Assaf & Al-Hejji also addressed that wherever there is effective project team there is strong decision makings, timely progress and good quality of technical deliverables (Assaf & Al-Hejji, 2006); Assaf, Al-Khalil, & Al-Hazmi stated the lack of effective management in the manufacturers team affect the materials and equipment delivery, where project managers start ordering the required materials very late, does not have the required resources to complete the products and does not book sub-suppliers slots, all these delay the start of production and delivery of the product (Assaf, Al-Khalil, & Al-Hazmi, 1995). Doloi, Zaneldin and El-Razek have mentioned in their papers the lack of effective management team and its importance, any project good performance start by having the right players and team, it is not a single party role, it is every stakeholders role to bring the right experienced team to deliver successfully the project, this will be obvious on the decisions, quality of the deliverables and protect the schedule and save project time (Doloi et al., 2012; E. Zaneldin, 2005; El-Razek et al., 2008). Fallahnejad, Faridi & El Sayegh, Fayek and Frimpong, all in their papers addressed the importance of strong project management team and they have also expressed the problems for not having the right team from the beginning of the project (Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Fayek et al., 2006; Frimpong et al., 2003). Hamzah, Han Kaliba, Muya, & Mumba extended the criticality of effective project team to cover the lead engineers, who should maintain the schedule by delivering the required engineering at the right time, instead of recycling the reviews and documents rejection by the client and project management consultancy team. Good and experienced project engineering team deliver the engineering documents with complete clarity and reduce the risks of the construction contractor during execution (Hamzah et al., 2011; Han et al., 2009;

Kaliba, Muya, & Mumba, 2009, 2009). Poor project management from the design consultant, client side and contractor all contribute to poor performance outcome.

Kumaraswamy & Chan mentioned the effective project management to address the construction contractor, where key decisions are required at certain times to compensate progress delays , this means strong project management can take fast and appropriate decisions to reinforce resources and compensate the shortage of resources as quick as required to improve the quality of work, this can be achieved if the construction contractor is equipped with strong decision making managers, otherwise the delays and poor quality will be extended to cover other areas and worsen the problem (Kumaraswamy & Chan, 1998). Le-Hoai also has addressed that the project leadership empower the project and make difference in the execution and decision making, (Le-Hoai et al., 2008); Long in his paper also talked about project management efficiency and client project management team could play major role towards project performance when project management team were involved early in the project, (2014 Long). The same was addressed and mentioned by various literatures; Majld & McCaffer, Marzouk & El-Rasas, but extended to cover inexperienced project team (Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014).

Mashayekhi Ali N. & Mazaheri Tahmasb, have mentioned the importance of having effective project management team from the client, designing consultant, manufacturers, construction contractor and subcontractor, having effective project management team play role on all the organization of the projects and create effective decision making, quality deliverables and reflect good project performance (Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Mortaheb also mentioned the value of having client decision making and fast response to various technical queries by the designing consultant and construction contractor (Mortaheb et al., 2013). Odeh & Battaineh, Ogunlana and Orangi have extended the importance of effective project management team from the client and construction contractor during the execution phase; i.e. during the construction, since having them at the construction location will encourage the others to be more productive and quick in taking decisions and will have direct impact on the progress as resources will be utilized optimally and increase the efficiency of the labors (Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011). Ramanathan has mentioned that a high quality of project team should add value to the entire progress and improve the productivity of other weak resources (Ramanathan et al., 2012). Salama, Hamid, & Keogh have also mentioned in their papers that they have found the decision making of key project management members affect the progress and avoid recycling of the work (Salama, Hamid, & Keogh, 2008). Others like Sambasivan & Soon, Sullivan & Harris, Sweis and Tumi in their papers have mentioned clearly the importance to have strong and effective project management team; not limited to the client organization but extended to cover the designer team, subcontractor along the main contractor, project management consultant and the manufactures (Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009). The role and value of effective management team was recorded in various literatures and majority of the presented papers emphasised this as a key factor behind project success if it is implemented from the beginning of the design phase.

Table (2.1) has summarized the literatures which have covered the lack of effective management factors and inexperienced project teams.

2.4.3. Insufficient team building

Insufficient team building between the stakeholders during the design phase and EPC was one of the factors contributed to poor performance of project. Mashayekhi Ali N. & Mazaheri Tahmasb in their paper have address the team building could play healthy role between the members since client and design key players were always in technical discussions, disputes and conflicts that impacted the entire project team, client rejection also to participate in team building was frustrating the team members, since they were under pressure to work extra hours to deliver the late progress and this affected their productivity, but having frequent team buildings play positively on the team spirit and keep them together as it break the tension among the client members and designer members which result in effective communication and ease the understanding between both parties (Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Merrow also addressed the team building as one of the critical factor behind poor performance since the client and construction teams always in conflict and fight in the meetings, however once they started having regular team buildings, then the communication among the peers increased and started to understand each other and finding solution to each problem (Merrow, 2012). Ramanathan also presented the team building as important factor to the project team to relieve the tension between the project management team and the same is extended to cover the stakeholders (Ramanathan et al., 2012). Sullivan & Harris have presented the advantages of team building between the project team in the same organization, i.e. between the client project team themselves and between the designer team members and the same between the construction team members, then the same should be stretched to cover the entire project stakeholders (1986Sullivan & Harris, 1986). Table (1) list down the literatures which addressed the factor of insufficient team buildings for poor project performance.

Client inappropriate organization structure was mentioned in several papers as one of the frequent encountered factor in many projects. Doloi in his paper mentioned that inappropriate organization and unclear responsibilities is one of the reasons behind poor communications that lead to poor quality deliverables, delay in document approval by the client, mislead the designing consultant and could lead to wrong decision making during the construction (Doloi et al., 2012). El-Razek also has mentioned similar problems of incomplete organization by the client due to which many decisions were either taken wrongly or late in the project, and also mentioned that inappropriate organization structure by the construction contractor and multi tasks assigned to limited resources leads to less supervision and mismanagement which cause delays. (El-Razek et al., 2008). Kumaraswamy & Chan have mentioned the importance of having strong organization structure from all the parties from the design phase; where key and critical decisions are taken and the most important stakeholder is the client to have complete and well established structure to ensure all the required technical knowledge and decisions are made unambiguously with minor changes. Usually the designing consultant also provide minimal manpower structure to reduce the running cost, this impact the deliverables and quality of work (Kumaraswamy & Chan, 1998). Mashayekhi

Ali N. & Mazaheri Tahmasb have commented the same with regard to inappropriate organization structure and how it impacts the quality of early and late activities in any major project, having well-structured organization by having complete engineering team and planning resources by the client helps the execution of each phase of the project and deliver the project with the required quality and in time (Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Odeh & Battaineh have addressed that having strong inspection team and organization by the client should improve the quality of the deliverables and discover shortfalls as early as possible during the manufacturing rather than identifying the problems during the commissioning of the systems, the same is applicable to the construction contractor to be established with complete and experienced quality inspection team to ensure all the systems and equipment arrive at the site free of defects and as per the project standard (Odeh & Battaineh, 2002). Ogunlana has highlighted the importance of establishing appropriate organization by all the project stakeholders, mainly during the construction phase where the project at the end and client operation must be involved and ready to take over the site, it was highlighted that in majority of the projects the late involvement of client end users cause severe delay due to unacceptance of many systems, so having appropriate organization from the design phase where the client end users are available and their inputs are included will lead to smooth commissioning and acceptance of the systems in the projects (Ogunlana et al., 1996). Ramanathan also mentioned the vital role could be played by the client end user if the organization is structured and involved them from the design phase, where all end users' lessons learnt and maintenance problems could be tackled during the design rather than during the commissioning of the systems (Ramanathan et al., 2012). Sambasivan & Soon, and Sweis have highlighted that having well-structured organization by the client will improve the quality of document approval and tackle problems with solution very early in the project (Sambasivan & Soon, 2007; Sweis et al., 2008). From the literature is was recorded how critical to have appropriate structured organization from all the parties; mainly from the client side to approve document at the right designing phase, to inspect the system during the manufacturing stage and to tackle all the operation and maintenance issues at the designing phase by the end users, also this applicable to have strong and appropriate structure by the designing consultant, providing high quality resources will improve the quality of the engineering deliverables and minimize the document rejection by the client. Table (1) lists out all the papers which have highlighted this factor.

2.4.4. Conflicts / Disputes between stakeholders

Conflicts / Disputes between stakeholders (owner, project team and Operations) factor was mentioned many times in the literature and it plays major role in the project performance. Afshari in his paper mentioned that client internal conflict between the engineering team and the end user caused many problems during the commissioning phase, where end users feedback on many previous encountered problems raised by the end users operation not considered at the design phase and conflict and dispute extended to involve client supply chain members where spare parts which should be available during the first year plant operation were delayed due to late order by the supply team (Afshari et al., 2010).; Al-Momani has highlighted the same, and how important to have good harmony between client key stakeholders and the client engineering and project team should involve the end user during the design phase and all other corporate support team to avoid any misalignment at the handover time among them (Al-Momani, 1999). Assaf & Al-Hejji, and Doloi have said that having operation and maintenance team by the client involved during the design will ensure all their lessons learnt and frequent problems are addressed during the design and they play major role in the HAZOP and 3D model reviews and approvals (Assaf & Al-Hejji, 2006; Doloi et al., 2012). Zaneldin also recorded in his survey that involving all client stakeholders will expedite the design documents and systems will be accepted by the end user if they were involved in the design phase since all their issues will be incorporated in the design phase (E. Zaneldin, 2005). El-Razek and Fallahnejad have addressed the importance of involving the operation and maintenance during the equipment inspections and acceptance at the manufacture site, which should help to identify all the problems very early in the manufacture site before shipping to the site (El-Razek et al., 2008; Fallahnejad, 2013). Hamzah has highlighted how important to involve the end user as early as possible in the early design phase and consider their experience in operating similar systems (Hamzah et al., 2011). Han and Haseeb also recorded that disagreement between client project team and end user cause major approval delay and change orders at very late stage of the projects (Han et al., 2009; Haseeb et al., 2011). Kumaraswamy & Chan have addressed to involve client end user during the design phase to approve the design and reduce change orders at later stage (Kumaraswamy & Chan, 1998). Marzouk & El-Rasas have suggested to have written design basis between the client internal stakeholders to minimize the conflict and record somehow the requirement of the end users (Marzouk & El-Rasas, 2014). Mortaheb in his paper mentioned that having the operation and maintenance team participated during the design phase will improve the design quality and reduce the late dispute between client project team and end users (Mortaheb et al., 2013). Odeh & Battaineh, and Ogunlana have emphasized on the value of having client operation very early in the design (Odeh & Battaineh, 2002; Ogunlana et al., 1996). Ramanathan also suggested to include client operation in the review engineering document list to ensure all their concerns are captured very early and to avoid future change orders and variations (Ramanathan et al., 2012).; Salama, Hamid, & Keogh, 2008 and Sambasivan & Soon in their papers highlighted that involving all the client stakeholder at the right time of the project reduce the internal client conflicts (Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007). Table (1) list the record of all the literatures which addressed the client internal conflict factor.

Project Manager does not have full authority factor was one of the literature recorded for cause of poor performance. Mashayekhi Ali N. & Mazaheri Tahmasb have mentioned limited authority by the client project management cause severe delay as no timely decisions were made, all the time client project manager must obtain approval from the internal authorities and committees, which requires to develop business case request and keeping the designing consultant standby awaiting for approval (Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Table (1) list out the literatures which addressed the factor on authority of Project Manager.

Long has mentioned that client insufficient & inexperienced management personnel were major factors in one of the executed projects, where owner inexperience manager made wrong and late decisions most of the times (Long, 2014). Table (2.1) list out the literature on inexperience management personnel from owner.

2.4.5. Frequent Owner/client Interference

Frequent Owner/client Interference during the design phase was one of the factors of late approvals and redesigning the activities. Zaneldin has addressed that in several projects, the client frequent interference in the designing phase cause re-do of the work and consume big effort by the designing consultant (E. Zaneldin, 2005). Marzouk & El-Rasas also highlighted the same factor and stated client less interference will help the other stakeholders such as designing consultant and project management team to focus and complete activities in a timely manner (Marzouk & El-Rasas, 2014). Mortaheb also addressed the same but he added client interference could be valued if it was made at the right time but frequent interference causes the project team to lose focus (Mortaheb et al., 2013). Odeh & Battaineh, Ramanathan, Sambasivan & Soon and Sweis have mentioned how bad client frequent interference delays the project schedule (Odeh & Battaineh, 2002; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Sweis et al., 2008). Table (2.1) is listing all the literature which addresses client frequent interference as a major poor performance and delay factors in the projects.

Excessive Bureaucracy in Owner's organization was a factor collected by several literatures, Assaf, Al-Khalil, & Al-Hazmi have mentioned owner bureaucracy destroy the project objectives and cause a delay in approval of documents (Assaf, Al-Khalil, & Al-Hazmi, 1995). Doloi also mentioned the same and client bureaucracy is a factor behind project design change orders or delay of payments for the construction contractor (Doloi et al., 2012). El-Razek, Fallahnejad, Faridi & El Sayegh, Ramanathan and Tumi have highlighted that client internal bureaucracy has impacted projects performance and caused severe delay to complete the projects on time (El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El Sayegh, 2006; Ramanathan et al., 2012; Tumi et al., 2009). Table (2.1) list the literatures which highlight the client bureaucracy as a delay or poor performance factor in the industry.

2.4.6. Slow Approvals and Slow Decision making by the Client

Issues regarding permissions / approvals from other stakeholders were recorded in several papers as a factor caused poor performance in the project. Alaghbari and Al-Momani both have mentioned the same in their papers, getting approvals from the client organization takes a very long time and causes standby by many stakeholders (Alaghbari et al., 2007; Al-Momani, 1999). Assaf & Al-Hejji, Assaf, Al-Khalil, & Al-Hazmi have mentioned getting permission from the government body for lands clearance and no objection certificates causes major delay in some of the projects (Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995). Doloi, Dr Patrick. X.W. Zou1, Zaneldin and others listed in the below table have highlighted that land permissions and other governmental approval take times and require massive coordination and their late involvement cause the project standby awaiting for approvals and permissions (Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005). Table (1) list down the literatures which addressed the factor of issues regarding permissions / approvals from other stakeholders for poor project performance.

Afshari has mentioned that client slow decision making is one of the factors behind project late delivery (Afshari et al., 2010). Alaghbari has mentioned the same, and client lack of staff involvement cause delay in documents approval and to finish the work in time (Alaghbari et al., 2007). Doloi and El-Razek, both have mentioned that client must be prepared with full staff to handle the project during the commissioning and handover (Doloi et. al. 2012; El-Razek et al., 2008). Faridi & El-Sayegh, Frimpong, Hamzah, Kumaraswamy & Chan, Marzouk & El-Rasas, Odeh & Battaineh, Ramanathan, Salama, Hamid, & Keogh, Sambasivan & Soon, Sweis and Tumi, all have stated that client lack of staff cause various delay during the design phase to approve documents, during the manufacturing to attend inspection and testing, during the review to attend and endorse designs and during construction to approve permits, also during the final pre-commissioning to approve and take over the systems (Faridi & El-Sayegh, 2006;

Frimpong et al., 2003; Hamzah et al., 2011; Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009). Table (2.1) summarize the literatures which have addressed the client lack of staff involvement as a cause of project poor performance and delay the project schedule.

Lack of IT use in communication and information Management was mentioned in one of the literatures; however, it was not emphasized in other papers. Salama, Hamid, & Keogh have mentioned that lack of IT and information management system was one of the factors behind poor communication and improper records (Salama, Hamid, & Keogh, 2008).

Lack of mechanism for recording, analyzing, and transferring project lessons learned was considered as a factor behind repeated projects poor performance. Afshari has mentioned that majority of client organization, designing consultant and construction contractor do not have clear mechanism to learn from their previous mistakes and they repeat the same mistake again and again (Afshari et al., 2010). Merrow also mentioned that some of the organization do have recording systems to record projects close out reports but there is no clear mechanism to guide them how to retrieve or bring the previous lessons to their next projects, if client learn from previous lessons then he could improve the project performance (Merrow, 2012). Mortaheb stated the same on proper recording or analyzing for projects lessons in the client organization (Mortaheb et al., 2013).

Inadequate control procedures from owner side to monitor the progress and delay was mentioned in several papers in different ways. Alaghbari has mentioned that client does not have proper tools or system to keep close monitor for projects progress (Alaghbari et al., 2007). Assaf & Al-Hejji have highlighted that if client is equipped with good progress analysis then he could be alerted for any slow progress or indications of delay (Assaf & Al-Hejji, 2006). Zaneldin mentioned the same that client is required to have full project progress monitoring and analysis for any forecasted delays (E. Zaneldin, 2005). El-Razek mentioned that planning and monitoring procedure must be clear in the contractor scope and experienced resources are provided to monitor the progress and highlight the project risks (El-Razek et al., 2008). Fallahnejad also clarified in his paper that poor procedure to monitor progress led to late actions by client and the responsible party (Fallahnejad, 2013). Faridi & El-Sayegh have also highlighted the same factor and suggested to provide closely monitor the progress reports and caution on any late deliverables and activities (Faridi & El-Sayegh 2006). Frimpong and Le-Hoai have also presented the importance of having clear procedure for designer and contractor to report progress and analysis of the risks in each stage of the project (Frimpong et al., 2003; Le-Hoai et al., 2008). Majld & McCaffer, Marzouk & El-Rasas, Odeh & Battaineh, Ogunlana, Ramanathan, Sambasivan & Soon, Sweis and Tumi, all in their papers have mentioned that poor control procedure and no strong monitoring from the client side is a cause of project delay (Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009). Table (below table mention the papers which have address the same factor.

2.4.7. Inaccurate Cost Estimate

Incomplete or inaccurate cost estimate by owner & EPC Contractors is a key factor for cost overrun by the client and claims by the contractor in many projects and is led to project failures. Dr Patrick highlighted that bad cost estimate by client lead to design and variations at later stages (Dr Patrick. X.W. Zou1, 2006). Zaneldin mentioned also cost estimate is one of the key factors behind project failure, since wrong estimate by construction contractor lead to cutting corners by the contractor and reduce the project quality to compensate the losses (E. Zaneldin, 2005). Frimpong mentioned that underestimating the cost by the designer could lead the client to wrong budgeting or cost inflations (Frimpong et al., 2003). Le-Hoai highlighted that wrong cost estimate lead the contractor to raise claims and variations and defeat the project quality and release resources to compensate his losses (Le-Hoai et al., 2008); Long stated the same in his paper, cost estimate is a key factor behind poor performance and budget and cost inflation (Long, 2014) Marzouk & El-Rasas, Merrow, Ogunlana, Ramanathan and Sweis, all in their papers mentioned how important for the client to have good cost estimate and how critical the contractor is provided with sufficient time to provide good commercial proposals for his bid (Marzouk & El-Rasas, 2014; Merrow, 2012; Ogunlana et al., 1996; Ramanathan et al., 2012; Sweis et al., 2008). Table (2.1) indicate the references of inaccurate cost estimate factor behind poor performance.

2.4.8. Poor Project Planning

Inadequate or improper planning/schedule from Owner to deliver the project is a key factor behind project late delivery and poor performance. This factor was mentioned in several papers as a major reason for poor performance. Orangi has mentioned that client wrong planning and schedule forced the designers to accept the required schedule and they are forced to meet it, this affected the quality of the design and many designing documents were incomplete (Orangi et al., 2011); Sullivan & Harris the same was mentioned by him, poor project overall schedule has affected the designing consultant quality and increase number of unqualified resources to meet the client unrealistic schedule (Sullivan & Harris, 1986). Odeh & Battaineh mentioned the same on the bidding duration by the client which does not allow enough time for the bidders to study the scope in details and leave many items unconsidered during the bidding (Odeh & Battaineh, 2002). Chanmeka mentioned that poor schedule estimate by client lead the construction contractor to accept unrealistic schedule and lately claim time extension or waiting for any opportunity for claims, also inadequate schedule compress the contractor to load more resources and less close supervisions thereby compromising on safety and quality (Chanmeka et al., 2012). Faridi & El-Sayegh, and Ramanathan in their papers mentioned that always clients provide unrealistic schedule for the design phase which leave the design poor and incomplete (Faridi & El-Sayegh, 2006; Ramanathan et al., 2012). Doloi, Fayek Dr Patrick have highlighted how important for the construction contractor to have realistic schedule to plan the activities safely and deliver the project without losses (Doloi et al., 2012; Fayek et al., 2006; Dr Patrick. X.W. Zou1, 2006). Merrow, Zaneldin, Sweis, Afshari, Hamzah, El-

Razek, Majld & McCaffer and Mashayekhi Ali N. & Mazaheri, all in their paper mentioned that in majority of the projects, client provide unrealistic schedule and lead to time extension and cost overrun by designers and construction contractors, which leads to poor performance project.; (Merrow, 2012; E. Zaneldin, 2005; Sweis et al., 2008; Afshari et al., 2010; Hamzah et al., 2011; El-Razek et al., 2008; Haseeb et al., 2011; Majld & McCaffer, 1998; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Marzouk & El-Rasas, 2014; Fallahnejad, 2013; Mortaheb et al., 2013; Al-Khalil & Al-Ghafly, 1999; Kumaraswamy & Chan, 1998; Sambasivan & Soon, 2007; Kaming et al., 1997; Long, 2014; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Tumi et al., 2009; Han et al., 2009; Ogunlana et al., 1996; Frimpong et al., 2003). Table(2.1) indicate the list of papers that mentioned this factor.

Poor estimation of labor productivity by EPC was one of the factors mentioned in various literatures. Alaghbari mentioned poor estimate for labor productivity ended the contractor with wrong cost estimate and cost overrun (Alaghbari et al., 2007). Al-Khalil & Al-Ghafly also highlighted poor labor productivity pushed the contractor to increase the manpower and face financial impacts (Al-Khalil & Al-Ghafly, 1999). Assaf & Al-Hejji also mentioned that mostly the contractor miscalculates the labor productivity or unfamiliar with labor law in the project country, which lead him to time and cost claims at later stage (Assaf & Al-Hejji, 2006). Poor labor productivity has contributed to contractor losses and unsafe construction (Assaf, Al-Khalil, & Al-Hazmi, 1995). The same was mentioned in Chanmeka paper that in many projects the construction contractor underestimate the labor and their poor productivity which force him to increase the labor size and face financial problems. Chanmeka, Doloi, Dr Patrick., El-Razek, Fallahnejad, Faridi & El-Sayegh, Fayek, Frimpong, Hamzah, Haseeb, Kaming, Kumaraswamy & Chan, Le-Hoai, Long, Marzouk & El-Rasas, Odeh & Battaineh, Ogunlana, Ramanathan, Salama, Hamid, & Keogh, Sambasivan & Soon, Sullivan & Harris and Sweis all in their paper mentioned that in majority of the projects, poor estimation of labor productivity by EPC, which leads to wrong cost estimate and cost overrun and poor performance project.; (Chanmeka et al., 2012). Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Fayek et al., 2006; Frimpong et al., 2003; Hamzah et al., 2011; Haseeb et al., 2011; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Long, 2014; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008). Table (2.1) also address the same factor in different literatures.

2.4.9. Delay in Documents Approval

Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor was mentioned in several papers and also considered as a factor causing poor performance. Afshari has mentioned this factor in his paper and client poor productivity affected the completion and readiness of the design document in time (Afshari et al., 2010). Assaf & Al-Hejji have mentioned that this factor which mainly cause severe delay for other sequential engineering documents to be developed awaiting client approval and review of preceding document (Assaf & Al-Hejji, 2006). Doloi highlighted this factor mainly affecting the manufactures production since they issue the document for approval before manufacturing or material orders and cannot risk and proceed with the production without approval to avoid rework, so it always affect the production which get delayed awaiting for client approval (Doloi et al., 2012). Faridi & El Sayegh have also mentioned client's slow approval impact the productivity and keeps the contractor or consultant between two options; either take the risk and proceed or hold the next step and wait for the document approvals (Faridi & El-Sayegh, 2006); Hamzah has also mentioned the value of client quick approval for the documents which allows the next step to begin as early as needed and avoid any standby by the consultant or the construction contractor (Hamzah et al., 2011); Kumaraswamy & Chan have highlighted that quick client response ensure the manufacturers timely production and avoid any delay (Kumaraswamy & Chan, 1998); Marzouk & El-Rasas, and Odeh & Battaineh both in their papers mentioned that one of the factors behind late project delivery is client slow approval of engineering documents (Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002). ; Ogunlana has considered the same factor in his papers and mentioned that longer approval duration by the client caused further delay by the contractor (Ogunlana et al., 1996). Ramanathan, Sambasivan & Soon, and Tumi; all in their papers highlighted that client slow approval lead to unnecessarily delay (Ramanathan et al., 2012; Sambasivan & Soon, 2007; Tumi et al., 2009). Table(2.1) list down the references where the client poor and slow productivity have been mentioned.

2.4.10. Poor Client Participation and Design Complexity

Lack of Client Participation in Major Milestones during Design is one of the factors mentioned in literatures, Mortaheb mentioned that client reluctance to participate in major reviews cause weak design and cause major changes at later stages (Mortaheb et al., 2013). Client participation play key role in project performance.

Mega size, Design complexity and complications of projects are one of the factors that cause poor performance. Assaf & Al-Hejji have highlighted large scale projects cause delays due to their size and the required resources (Assaf & Al-Hejji, 2006). Chanmeka did address the same and highlighted that large scale projects with weak selection of designer cause a delay in the project (Chanmeka et al., 2012). Haseeb, Mashayekhi & Mazaheri have mentioned in their papers that size and complexity of project with bad selection of construction contractor and wrong designer lead to poor performance and delays with bad quality product (Haseeb et al., 2011; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Ogunlana also mentioned the same about the complexity of projects could lead to delay if incompetent designer or contractor were chosen (Ogunlana et al., 1996). Sullivan & Harris have mentioned the large size of projects leads to wrong delivery estimation and cause delay due to its size (Sullivan & Harris, 1986). Table(2.1) list down the references related to size of the project.

2.4.11. Design Changes and Variations

Design Variations or changes in client requirement factor could be the most frequent and repeated factor behind delays and claims. Ahsan & Gunawan have highlighted that client changes are the dominant delay factor (Ahsan & Gunawan, 2010). Alaghbari has mentioned client frequent changes at the design phase cause major changes to the designing documents and lead to poor quality of design (Alaghbari et al., 2007). Al-Khalil & Al-Ghafly have highlighted that client changes at late stage of the design leave the consultant with incomplete design and poor deliverables (Al-Khalil & Al-Ghafly, 1999). Al-Momani mentioned that changes always extend the project schedule and cause delays (Al-Momani, 1999). Assaf & Al-Hejji mentioned the changes by the client during the execution caused further delays and high cost since it impacts the designing documents and ordered materials, this cause real schedule extension and variations (Assaf & Al-Hejji, 2006, Assaf, Al-Khalil, & Al-Hazmi, 1995). Doloi and Dr Patrick both have highlighted this factor as a major factor behind project delay and major commercial claims by the contractors (Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006). Zaneldin, El-Razek, Fallahnejad, Faridi & El-Sayegh, all did consider this factor as major factor behind delay and schedule extension by the designer and contractor (E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El Sayegh, 2006). Hamzah, Han, Kaliba, Muya, & Mumba have mentioned that in majority of the cases there is a real cause for the change orders which comes with advantages to the projects, however it always extend the schedule and cost (Hamzah et al., 2011; Han et al., 2009; Kaliba, Muya, & Mumba, 2009). Kaming, Kumaraswamy & Chan, Le-Hoai have mentioned the reasons behind the changes and there is advantages of change orders by the client at all the phases (Kaming et al., 1997; Kumaraswamy & Chan, 1998). Le-Hoai , Long, Marzouk, Mashayekhi, Mortaheb, Odeh, Ogunlana, Orangi, Ramanathan , Salama, Sambasivan, Sullivan , Sweis and Tumi all in their papers mentioned that in majority of the projects, design variations or changes in client requirement factor could be the most frequent and repeated factor behind delays and claims and poor performance project.; (Le-Hoai et al., 2008; Long, 2014; Marzouk & El-Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009). Table (2.1) mentions the references for the change order factor.

2.4.12. Poor Scope Definition

Inadequate project Objective and scope definition by Owner and FEED designer factor was addressed in several papers, where the client does not clearly specify the project objectives and unclear scope definition, which leads to different direction by designer team and by the construction contractor at later scope. Alaghbari has confirmed this factor in his paper (Alaghbari et al., 2007). Chanmeka also mentioned the same, and this led to frequent changes in the design due to client unclear objectives (Chanmeka et al., 2012). Dr Patrick has mentioned this factor and it is considered as a reason for change orders by the client and consequently cause time extension and delays (Dr Patrick. X.W. Zou1, 2006). Merrow has highlighted that inadequate objectives create problems in client organization, since each client stakeholder come with his own scope and requirement which is different from another client stakeholder, this cause more confusion to the designer and construction contractor (Merrow, 2012). Mortaheb did also mentioned this factor as a reason which leads to frequent changes and poor performance (Mortaheb et al., 2013). Ramanathan has emphasized that unclear scope definition leads to argument between the client key members and conflict at later stage (Ramanathan et al., 2012). Salama, Hamid, & Keogh and Tumi, both mentioned the same and considered inadequate scope definition as a factor for poor performance, also mentioned that system sizing and design standard keeps changing once the objectives and scope definitions are unclear (Salama, Hamid, & Keogh, 2008; Tumi et al., 2009).

2.4.13. Poor Engineering Team

Lack of engineering clear roles/goals factor was highlighted by the literature and mentioned in several papers. Alaghbari has addressed this factor as a reason cause frequent changes and lead to delays and claims (Alaghbari et al., 2007). Chanmeka mentioned this factor in his paper and how it impacts the subsequent design elements. If the engineering roles are unclear then this leads to poor quality of engineering deliverables which are key document for construction and estimates (Chanmeka et al., 2012). Dr Patrick has mentioned the same factor in his paper and how important to clarify the engineering goals from day one (Dr

Patrick. X.W. Zou1, 2006). Merrow addressed the same in his paper and clear engineering role lead to good quality of design and avoid any engineering rework (Merrow, 2012). Mortaheb mentioned that this factor confirm that the project started with wrong engineering goals which could lead to major schedule and cost impact (Mortaheb et al., 2013). Ramanathan has mentioned that one of the project success is to identify the engineering role very early in the project (Ramanathan et al., 2012). Salama, Hamid, & Keogh also addressed the same factor and how critical to ensure all the stakeholders understand the engineering role very clear and maintain it to avoid any further problems with the design (Salama, Hamid, & Keogh, 2008); Tumi in his paper also highlighted that engineering role must be clear and agreed between all the stakeholders inside client organization and between the designing team organization and between the client and designing consultant (Tumi et al., 2009).

Poor quality of deliverables by FEED Designer is very critical factor which contribute to poor performance since it impacts the contractor and manufacturers product quality. Alaghbari did mention that poor quality of feed document lead to two ways of execution, one underestimate the requirements and one overestimate the requirement, the underestimate propose wrong design and later lead to variation and poor quality and other leads to loss to the project (Alaghbari et al., 2007). Fallahnejad mentioned poor quality of FEED means misunderstanding of the scope by the construction bidders which leads to schedule delay and dispute at the execution phase (Fallahnejad, 2013). Mortaheb similar explanation was presented in his paper, where the incomplete designs leads to surprises at late stage by the detailed engineering work under the construction contractor which could lead to design variation or severe technical deviations by the contractor (Mortaheb et al., 2013). Table(2.1) list down the references of the factor.

2.4.14. Insufficient Design Information from Owner

Delayed or insufficient design information from owner factor is mentioned very frequently in the literatures. All the papers repeat the same factor and consider it as one of the main reason for schedule delay caused by the client. Afshari did mention this factor in his paper which led to severe schedule delay (Afshari et al., 2010). Alaghbari also highlighted the same in his paper and blamed the client poor response to the designing consultant clarification as main reason for incomplete design (Alaghbari et al., 2007). Al-Khalil & Al-Ghafly also blamed the client insufficient information and late submission to the consultant as a reason for standby by the consultant (Al-Khalil & Al-Ghafly, 1999). Assaf & Al-Hejji also presented the same factor and mentioned how important that client provide all the required information as early as possible to the designing consultant to ensure the design is complete as per the schedule (Assaf & Al-Hejji, 2006). Al-Khalil, & Al-Hazmi in their paper mentioned that one of the project success is client to timely submit clear and all the required information to the designing consultant (Al-Khalil, & Al-Hazmi, 1995). Doloi consider this factor as poor coordination between the consultant and the client project team (Doloi et al., 2012). Dr Patrick also presented this factor and highlighted that consultant must obtain the information during the bidding stage to ensure this information is provided by the client as early as possible (Dr Patrick. X.W. Zou1, 2006). Zaneldin, El-Razek and Fallahnejad, all have addressed the same factor and blamed the client project team as a source of delays and support the designing team (E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013). ; Faridi & ElSayegh, Frimpong, Haseeb, Kumaraswamy & Chan, Le-Hoai, Marzouk & El-Rasas, Odeh & Battaineh, Ogunlana, Orangi, Ramanathan, Salama, Hamid, & Keogh, Sambasivan & Soon, Sullivan & Harris, Tumi, all in their papers addressed that client providing late designing information caused delays to complete the design (Faridi & El Sayegh, 2006; Frimpong et al., 2003; Haseeb et al., 2011; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Tumi et al., 2009). Table (2.1) lists down all the references of the papers on the above delay factor.

2.4.15. Poor Communication Between Stakeholders

Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance) factor was considered by many papers and it leads to poor quality of design and delays in the project. Afshari has mentioned this factor as poor communication between stakeholders during the design leads to delay in the designing documents (Afshari et al., 2010). Alaghbari also repeated the same comments in his paper and stated that the communication between all stakeholders is very important during the design phase to ensure all the comments are captured as early as possible in the design (Alaghbari et al., 2007) Assaf & Al-Hejji also mentioned how important to establish a clear and strong communication between the client stakeholders and the designing consultant (Assaf & Al-Hejji, 2006). Doloi in his paper mentioned that late and weak communication during the design phase between client project team and end user cause many problems during the handover and operation of the plant (Doloi et al., 2012). Dr Patrick also mentioned that client project team poor communication with the internal stakeholder cause various problems at the approval of the systems during the commissioning (Dr Patrick. X.W Zou1, 2006). Zaneldin has addressed this factor in his paper and highlighted the importance to integrate and communicate with all the client stakeholders and the designing consultant (E. Zaneldin, 2005). Fallahnejad also mentioned that client project team should involve the end user from day one and end-user must be part of the client project team during the designing phase (Fallahnejad, 2013). Fayek, Hamzah, and Haseeb all the three in their papers mentioned this factor as a successful factor if client considered to improve the communication between the FEED consultant and his internal stakeholders (Fayek et al., 2006; Hamzah et al., 2011; Haseeb et al., 2011). Kumaraswamy & Chan and Marzouk & El-Rasas in their paper mentioned this factor and how important to record the communication and to develop responsibility and communication matrix to include all the stakeholders (Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014).; Mortaheb, Odeh & Battaineh, Ogunlana, Orangi, Ramanathan, Salama, Hamid & Keogh, Sambasivan & Soon, Sweis and Tumi, all did mention this factor in their papers and considered client poor internal communication as a reason for delays and poor quality of designing documents (Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012;

Salama, Hamid & Keogh, 2008; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009). Table(2.1) list all the references for this factor.

2.4.16. Documents Inconsistency and Outdated Designs

Inconsistency between specifications, prevailing international standards and owner's procedures / Specifications factor was mentioned in several papers and it cause delays and quality problems. Afshari did mention this factor lead to delay during the execution mainly (Afshari et al., 2010). Al-Momani also mentioned the inconsistency between client specification and international standard must be resolved and cleared during the design phase under (Al-Momani, 1999). Assaf & Al-Hejji have mentioned in their paper that inconsistency between client procedure and international standard heavily affect the manufacturers, since their products comply to international standard and deviating from that to client specification could lead them to major changes in their design (Assaf & Al-Hejji, 2006). Assaf, Al-Khalil & Al-Hazmi also mentioned that designing consultant must clear any inconsistency between client specification and the international standards (Assaf, Al-Khalil & Al-Hazmi, 1995). Doloi has recorded the same factor in his paper and considered that data sheets and specifications during the design must be consistent between the client requirements and the international standards (Doloi et al., 2012); Zaneldin also presented this factor and mentioned how this factor affect the vendors and manufacturers which at the end lead to delays and additional cost to comply to this requirement (E. Zaneldin, 2005). El-Razek, Fallahnejad, Faridi & El Sayegh, in their papers have address the inconsistency problems and how this is reflected during the execution (El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El Sayegh, 2006). Hamzah, Haseeb, Kaming, Kumaraswamy & Chan, Le-Hoai, Majld & McCaffer, Marzouk & El-Rasas, Ogunlana, Orangi, Ramanathan, Salama, Hamid, & Keogh, Sweis, Tumi, all in their papers mentioned similar feedback and confirmed that the studied projects showed that inconsistency between client specifications and international procedures and standards caused a big problem to the manufacturers and the construction contractor who buy the systems and equipment and always ended up with additional cost or technical deviation from the original scope and keep the production on hold till these technical conflicts are resolved. Also it was mentioned that the designing consultant must play major role to waive these inconsistencies and must develop a clear specification and data sheets to eliminate this type of contradictions (Hamzah et al., 2011; Haseeb et al., 2011; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Long, 2014; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sweis et al., 2008; Tumi et al., 2009). Table(2.1) list down all the references which have addressed inconsistency and absence of clear acceptance criteria as a major delay factor in the Oil & Gas industry.

Outdated design Software factor was presented in few papers as a factor behind poor performance. Assaf & Al-Hejji in their paper have mentioned this factor plays major role in the delay and poor quality of deliverables (Assaf & Al-Hejji, 2006). Mortaheb also mentioned that same smart software and old revisions causes major mismatching and problems at later stage and systems could not read the old versions (Mortaheb et al., 2013).

Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding factor was frequently mentioned in the literatures and always blaming the client for choosing the wrong contracting strategy. Al-Khalil & Al-Ghafly has mentioned that client choosing the contract type without considering the designing consultant requirement and preference, always lead to incomplete designs since the consultant is forced to complete the work within limited time or cost (Al-Khalil & Al-Ghafly, 1999). Assaf & Al-Hejji also mentioned choosing the right contract type for the FEED help the consultant to develop high quality documents since they can spare high experienced engineering team for the project, but once the project contract type is lump sum then the designing consultant starts to save cost by engaging cheaper engineering resources and this at the end cause poor quality and incomplete design in some cases (Assaf & Al-Hejji, 2006). Doloi, Dr Patrick and Zaneldin have highlighted that choosing the right contract type minimizes the risk on the designing consultant and also on the construction contractor and could deliver good quality product at the end of the project (Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005). Fallahnejad mentioned also the bidding strategy and to award to the technical accepted lowest commercial is not the right strategy and client suffer during the execution (Fallahnejad, 2013). Fayek has presented the same and mentioned that commercially lowest is not always is the right awarding strategy, since many bidders underestimate the requirement due to the short bidding duration and once they are awarded they start suffering and claiming losses in the project so quality and face resistance to change by the construction contractor (Fayek et al., 2006); Hamzah, Han and Haseeb, all in their papers mentioned that client awarding the project to the lowest commercial strategy must be reevaluated (Hamzah et al., 2011; Han et al., 2009; Haseeb et al., 2011). Kumaraswamy & Chan, and Long also have addressed that client sending wrong and incomplete bidding instructions during the bidding stage cause misunderstanding and claims by the contractor during the execution (Kumaraswamy & Chan, 1998; Long, 2014). Majld & McCaffer and Marzouk & El-Rasas have listed inappropriate bidding instructions by the client during the bidding stage cause further risk on the bidders and misunderstanding among them (Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014). Odeh & Battaineh and Ramanathan, have listed the client award strategy to the lowest commercial bidder is a major factor behind poor quality of the deliverables and delays to meet schedules (Odeh & Battaineh, 2002; Ramanathan et al., 2012). Salama, Hamid & Keogh, Sambasivan & Soon, Sullivan & Harris and Tumi, have listed this factor as a major factor behind poor quality and claims at later stage and not all the lowest commercial award was completed on time and quality (Salama, Hamid & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Tumi et al., 2009). Table(2.1) list down all the references behind this factor.

2.4.17. Delay in Bidding and Poor Contractors Experiences

Delay in Tendering and award schedule factor was mentioned in few papers. Ahsan & Gunawan have mentioned that delay in tendering and award schedule cause problems, since the awarded contractor or consultant build his pricing based on the available resources and time, changing or delaying this could engage the contractor with other project and lose the resources for this project (Ahsan & Gunawan, 2010). Salama, Hamid & Keogh have mentioned the same in their papers that contractor could be awarded another project and have shortage of resources and end up by delaying the lately awarded project or divide the resources among both project and suffer delays in both (Salama, Hamid & Keogh, 2008).

Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors were addressed in several papers. Afshari has addressed poor contractor experience was a major factor behind project delay (Afshari et al., 2010). Ahsan & Gunawan in their papers have mentioned that contractor unfamiliar with local regulations cost them time and money (Ahsan & Gunawan, 2010). Alaghbari also mentioned similar factors were contractors poor understanding of the local laws led to project delays (Alaghbari et al., 2007). Assaf & Al-Hejji have mentioned that lack of knowledge in the social understanding for contractor was a factor behind late approvals and poor labor productivities (Assaf & Al-Hejji, 2006). Doloi tackled the same factors in his papers, where he stated understanding the local culture and unfamiliar with the local law required contractor to spend more time and investment to resolve the approvals and labor problems (Doloi et al., 2012). Dr Patrick also mentioned the same in his paper where he listed inadequate contract experience is a factor behind poor performance and claims (Dr Patrick. X.W. Zou1, 2006). Zaneldin has also referred to the same factors and mentioned that understanding the local culture and labor law is very important to maximize the labor productivities (E. Zaneldin, 2005). Fallahnejad and Faridi & El-Sayegh in their papers have listed inadequate contractor experience cause poor quality product and delays in the project (Fallahnejad, 2013; Faridi & El-Sayegh, 2006). Hamzah mentioned that governmental regulation and local law must be understood by the contractors or to engage local contractor to overcome this problem (Hamzah et al., 2011). Haseeb and Kumaraswamy & Chan have also mentioned engaging local subcontractor resolved the local law and culture problems with the international contractors (Haseeb et al., 2011; Kumaraswamy & Chan, 1998). Le-Hoai also encouraged to involve local subcontractor to eliminate local experience and social problems with authorities (Le-Hoai et al., 2008). Marzouk & El-Rasas and Mashayekhi & Mazaheri also listed inadequate contractor experience as a factor behind poor performance and poor local subcontractor also was mentioned in their list (Marzouk & El-Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010). Odeh & Battaineh have mentioned poor experience of local contractor was a major delay factor in major projects (Odeh & Battaineh, 2002). Orangi, Ramanathan, Salama, Hamid & Keogh, Sambasivan & Soon, Sullivan & Harris, Sweis and Tumi, have mentioned in their papers that poor experience of the main contractor and the local subcontractor was one of the factors behind delays, poor performance of several projects (Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009). Table(2.1) list down all the reference related to inadequate of contractor experience and unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors.

2.4.18. Delay in Procurement and Mobilization of Teams

Delay in procurement by Contractor factor was mentioned in several papers and literatures. Afshari and Ahsan & Gunawan have mentioned in their papers contractor delay to procure the materials caused delay in majority of the projects (Afshari et al., 2010; Ahsan & Gunawan, 2010; Alaghbari et al., 2007). Al-Momani has highlighted the same and mentioned late approval by client which led to late procurement by contractor cause poor quality of products and late delivery of materials (Al-Momani, 1999). Assaf & Al-Hejji, and Assaf, Al-Khalil & Al-Hazmi have mentioned that contractor long negotiation to obtain low prices in the procurement which cause late placement of procurement orders and cause project delays (Assaf & Al-Hejji, 2006; Assaf, Al-Khalil & Al-Hazmi, 1995). Doloi also highlighted in his paper that contractor late issuing materials orders for various reasons causing late delivery of materials at site and this lead to slow down the installation and other construction activities which eventually contribute to poor performance and delay the schedule (Doloi et al., 2012). Zaneldin, El-Razek, Fallahnejad, Faridi & El-Sayegh in their papers also highlighted that client late approvals could impact contractor issuing purchase orders for materials which will have further implication on the overall delivery schedule of the project (Zaneldin, El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006). Frimpong has also mentioned contractor approach to obtain low prices lead him to place purchase orders very late in the projects which eventually impact the material delivery and installations (Frimpong et al., 2003). Others in their papers like; Hamzah, Haseeb, Kaliba, Muya & Mumba, Kaming, Kumaraswamy & Chan, Le-Hoai, Majld & McCaffer, Marzouk & El-Rasas, Odeh & Battaineh, Ogunlana, Orangi, Ramanathan, Salama, Hamid, & Keogh, Sambasivan & Soon, Sullivan & Harris, Sweis Tumi; have stated the same factor and recorded that materials late purchase cause subsequent delay for other activities and lead to late delivery and delay the project schedule (Hamzah et al., 2011; Haseeb et al., 2011; Kaliba, Muya & Mumba, 2009; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009).

Financial issue of Contractor during execution is a factor that contributes to poor performance and delay. Ahsan & Gunawan have mentioned this factor as one of the common factor behind late project delivery (Ahsan & Gunawan, 2010). Alaghbari and Al-Khalil & Al-Ghafly have mentioned that contractor financial problems impact progress since delaying labors salaries lead to low productivities and strikes by the labor and lead to delays (Alaghbari et al., 2007; Al-Khalil & Al-Ghafly, 1999). Assaf & Al-Hejji also mentioned that contractor financial difficulties lead to late payments to subcontractors and manufactures which leads to delay and stoppage of work (Assaf & Al-Hejji), 2006; others like; Assaf, Al-Khalil & Al-Hazmi, have stated similar reasons for late progress (Assaf, Al-Khalil, & Al-Hazmi, 1995).

Delay in mobilization during Design & EPC by consultant or construction contractors is a factor that leads to delays and poor performances. Assaf & Al-Hejji and Long, have included this factor part of a list that cause project completion with poor performance (Assaf & Al-Hejji, 2006; Long, 2014). Majld & McCaffer also have mentioned that consultant late mobilization of the required resources leads to slow start and late end (Majld & McCaffer, 1998). Marzouk & El-Rasas and Sweis, both have mentioned late mobilizations in their paper and contractor slow or late mobilization affect the early progress and cannot recovery lately (Marzouk & El-Rasas, 2014; Sweis et al., 2008).

Table (2.1) below shows the grouped factors referred in individual Literature and how many times were repeated and confirmed by individual papers.

Sr. No	Factors	References	No of Ref
1	Lack of effective Project Management. Inadequate experience of project team from all parties	Afshari et al., 2010; Ahsan & Gunawan, 2010; Alaghbari et al., 2007; Al-Momani, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Fayek et al., 2006; Frimpong et al., 2003; Hamzah et al., 2011; Han et al., 2009; Kaliba, Muya, & Mumba, 2009; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Long, 2014; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009	**32**
2	Insufficient team building during design and EPC	Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Merrow, 2012; Ramanathan et al., 2012; Sullivan & Harris, 1986	**4**
3	Inappropriate overall organization structure linking all project teams.	Doloi et al., 2012; El-Razek et al., 2008; Kumaraswamy & Chan, 1998; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Sweis et al., 2008	**9**

4	Conflicts / Disputes between stakeholders (owner, project team and Operations)	Afshari et al., 2010; Al-Momani, 1999; Assaf & Al-Hejji, 2006; Doloi et al., 2012; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Hamzah et al., 2011; Han et al., 2009; Haseeb et al., 2011; Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014; Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007	**18**
5	Project Manager does not have full authority.	Mashayekhi Ali N. & Mazaheri Tahmasb, 2010	**1**
6	Insufficient & inexperienced management personnel from Owner.	Long, 2014	**1**
7	Frequent Owner Interference.	E. Zaneldin, 2005; Marzouk & El-Rasas, 2014; Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Sweis et al., 2008	**7**
8	Excessive Bureaucracy in Owner's organization.	Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Ramanathan et al., 2012; Tumi et al., 2009	**7**
9	Issues regarding permissions / approvals from other stakeholders	Alaghbari et al., 2007; Al-Momani, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Hamzah et al., 2011; Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Tumi et al., 2009	**25**
10	Slow decision making & Lack of staff involvement from Owner side.	Afshari et al., 2010; Alaghbari et al., 2007; Assaf & Al-Hejji, 2006; Doloi et al., 2012; El-Razek et al., 2008; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Hamzah et al., 2011; Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009	**16**
11	Lack of IT use in communication and information Management	Salama, Hamid, & Keogh, 2008	**1**

12	Lack of mechanism for recording, analyzing, and transferring project lessons learned.	Afshari et al., 2010; Merrow, 2012; Mortaheb et al., 2013	**3**
13	Inadequate control procedures from owner side to monitor the progress and delay.	Alaghbari et al., 2007; Assaf & Al-Hejji, 2006; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Le-Hoai et al., 2008; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009	**16**
14	Incomplete or inaccurate cost estimate by owner & EPC Contractors.	Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; Frimpong et al., 2003; Le-Hoai et al., 2008; Long, 2014; Marzouk & El-Rasas, 2014; Merrow, 2012; Ogunlana et al., 1996; Ramanathan et al., 2012; Sweis et al., 2008	**10**
15	Inadequate or improper planning/schedule from Owner to deliver the project	Orangi et al., 2011; Sullivan & Harris, 1986; Odeh & Battaineh, 2002; Chanmeka et al., 2012; Faridi & El-Sayegh, 2006; Ramanathan et al., 2012; Doloi et al., 2012; Fayek et al., 2006; Dr Patrick. X.W. Zou1, 2006; Merrow, 2012; E. Zaneldin, 2005; Sweis et al., 2008; Afshari et al., 2010; Hamzah et al., 2011; El-Razek et al., 2008; Haseeb et al., 2011; Majld & McCaffer, 1998; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Marzouk & El-Rasas, 2014; Fallahnejad, 2013; Mortaheb et al., 2013; Al-Khalil & Al-Ghafly, 1999; Kumaraswamy & Chan, 1998; Sambasivan & Soon, 2007; Kaming et al., 1997; Long, 2014; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Tumi et al., 2009; Han et al., 2009; Ogunlana et al., 1996; Frimpong et al., 2003	**32**
16	Poor estimation of labor productivity by EPC	Alaghbari et al., 2007; Al-Khalil & Al-Ghafly, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Chanmeka et al., 2012; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Fayek et al., 2006; Frimpong et al., 2003; Hamzah et al., 2011; Haseeb et al., 2011; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Long, 2014; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008	**26**

17	Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor	Afshari et al., 2010; Assaf & Al-Hejji, 2006; Doloi et al., 2012; Faridi & El-Sayegh, 2006; Hamzah et al., 2011; Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Ramanathan et al., 2012; Sambasivan & Soon, 2007; Tumi et al., 2009	**12**
18	Lack of Client Participation in Major Milestones during Design	Mortaheb et al., 2013	**1**
19	Mega size, Design complexity and complications.	Assaf & Al-Hejji, 2006; Chanmeka et al., 2012; Haseeb et al., 2011; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Ogunlana et al., 1996; Sullivan & Harris, 1986	**6**
20	Design Variations or changes in client requirement	Ahsan & Gunawan, 2010; Alaghbari et al., 2007; Al-Khalil & Al-Ghafly, 1999; Al-Momani, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Hamzah et al., 2011; Han et al., 2009; Kaliba, Muya, & Mumba, 2009; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Long, 2014; Marzouk & El-Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009	**31**
21	Inadequate project Objective and scope definition by Owner and FEED designer.	Alaghbari et al., 2007; Chanmeka et al., 2012; Dr Patrick. X.W. Zou1, 2006; Merrow, 2012; Mortaheb et al., 2013; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Tumi et al., 2009	**9**
22	Lack of Engineering clear roles/goals	Mortaheb et al., 2013	**1**
23	Poor quality of deliverables by FEED Designer	Alaghbari et al., 2007; Fallahnejad, 2013; Mortaheb et al., 2013	**3**

24	Delayed or insufficient design information from owner	Afshari et al., 2010; Alaghbari et al., 2007; Al-Khalil & Al-Ghafly, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Haseeb et al., 2011; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Tumi et al., 2009	**31**
25	Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance)	Afshari et al., 2010; Alaghbari et al., 2007; Assaf & Al-Hejji, 2006; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; Fallahnejad, 2013; Fayek et al., 2006; Hamzah et al., 2011; Haseeb et al., 2011; Kumaraswamy & Chan, 1998; Marzouk & El-Rasas, 2014; Mortaheb et al., 2013; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009	**21**
26	Inconsistency between specification, prevailing international standards and owner's procedures / Specifications	Afshari et al., 2010; Al-Momani, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Hamzah et al., 2011; Haseeb et al., 2011; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Long, 2014; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sweis et al., 2008; Tumi et al., 2009	**31**
27	Outdated design Software	Assaf & Al-Hejji, 2006; Mortaheb et al., 2013	**2**
28	Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding.	Al-Khalil & Al-Ghafly, 1999; Assaf & Al-Hejji, 2006; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; Fallahnejad, 2013; Fayek et al., 2006; Hamzah et al., 2011; Han et al., 2009; Haseeb et al., 2011; Kumaraswamy & Chan, 1998; Long, 2014; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Tumi et al., 2009	**24**

29	Delay in Tendering and award schedule	Ahsan & Gunawan, 2010; Salama, Hamid, & Keogh, 2008	**2**
30	Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors.	Afshari et al., 2010; Ahsan & Gunawan, 2010; Alaghbari et al., 2007; Assaf & Al-Hejji, 2006; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Hamzah et al., 2011; Haseeb et al., 2011; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Marzouk & El-Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Odeh & Battaineh, 2002; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009	**35**
31	Delay in procurement by Contractor	Afshari et al., 2010; Ahsan & Gunawan, 2010; Alaghbari et al., 2007; Al-Momani, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Hamzah et al., 2011; Haseeb et al., 2011; Kaliba, Muya, & Mumba, 2009; Kaming et al., 1997; Kumaraswamy & Chan, 1998; Le-Hoai et al., 2008; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Odeh & Battaineh, 2002; Ogunlana et al., 1996; Orangi et al., 2011; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sullivan & Harris, 1986; Sweis et al., 2008; Tumi et al., 2009	**29**
32	Financial issues of Contractor during execution	Ahsan & Gunawan, 2010; Alaghbari et al., 2007; Al-Khalil & Al-Ghafly, 1999; Assaf & Al-Hejji, 2006; Assaf, Al-Khalil, & Al-Hazmi, 1995; Doloi et al., 2012; Dr Patrick. X.W. Zou1, 2006; E. Zaneldin, 2005; El-Razek et al., 2008; Fallahnejad, 2013; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Hamzah et al., 2011; Kaliba, Muya, & Mumba, 2009; Le-Hoai et al., 2008; Marzouk & El-Rasas, 2014; Mashayekhi Ali N. & Mazaheri Tahmasb, 2010; Ogunlana et al., 1996; Ramanathan et al., 2012; Salama, Hamid, & Keogh, 2008; Sambasivan & Soon, 2007; Sweis et al., 2008; Tumi et al., 2009	**23**
33	Delay in mobilization during Design & EPC	Assaf & Al-Hejji, 2006; Long, 2014; Majld & McCaffer, 1998; Marzouk & El-Rasas, 2014; Sweis et al., 2008	**5**

Table (2.1) Delay Factors and key references

2.5 Stage Gate Project Management Process

Majority of the Oil & Gas Projects executed worldwide are managed by Stage-Gate Project Management Process (Walkup and Ligon, 2006) the statement has been supported by Robert Cooper, who has widely published on Stage-Gate (Cooper, 2008). Ajamian & Koen (2002) also quoted that Traditional Stage-Gate™ (SG) (Cooper 1993) or PACE® processes (McGrath and Akiyama 1996) have limitations to address high-risk technologies, which is a major cause of cancellation or significant delay in new product development projects (Ajamian & Koen, 2002). Large projects in the oil and gas industry face challenges as they become increasingly complex and technologically demanding (Bain & Company, 2013). This section focuses on the Stage-Gate Project Management Process and the Project Delivery methods.

2.5.1. History of Development for Project Management Process (Stage-Gate)

Robert Cooper (1994), as he describes, earliest Schemes of New Product Development was developed by NASA in 1960s, known better as Phased Review Process. This was an elaborate process for working with contractors and suppliers in space projects which had distinct phases for product development which had review points at the end of each phase (Cooper, 1994). In this First generation model development was broken into sequential phases to systematize and control work with contractors and suppliers on space projects (Verworn and Herstatt, 2002). As Vervon puts it “Inputs and outputs for each phase were defined and a management review was held at the end of every phase to decide on the continuation of a project (“go-no-go”)”. This process had many disadvantages such as the linear process was very time consuming leading to huge delays. Also the Functional departments handled the activities in isolation (Conway & Steward, 2008; Trott, 2008). First Generation Phased Review Process is represented by the figure below.

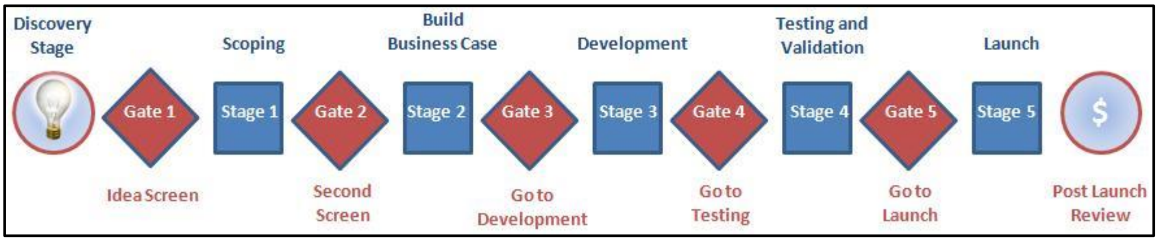


Figure (2.5) First Generation Phased Review Process
Source: NASA 1960; COOPER 1999; PROPS 1987

The figure shows the sequence of implementing a project from the idea discovery to the launching it. So once the idea is discovered it moves to idea screen gate, where the idea is looked at from all the angles to see its feasibility, this gate decides whether this idea should move on or stop here. Once the idea moves from this gate, then it move to the scope definition and identifying the idea requirements, this is called scoping stage, the scoping requirement also must pass through the second gate which is second screening gate, then it moves to second stage and it is called build a business case, there further details is specify here, like idea investment cost, idea challenges, idea duration and other high level requirement, the builds business case stage moves to third gate for approval to further development, this is called development gate then the development moves to stage three for clear idea development scoping, where the ide must be constructed and developed, here the idea will move to the testing gate, and it is called testing gate and from here the idea moves to testing and validation stage, where all the testing and validation is executed at this stage, once this gate is completed then it goes to the launch gate for launching stage, where the initial idea is launched and presented. By these stages and gates the stakeholders ensure a systematic process is in place to identify and report any improvement action is required.

The subsequent model of stage gate, As Cooper (1994) terms as Second generation process, had considerable upgrades over the linear, design oriented & highly functional first generation phased review process. It was considerably cross-functional, wherein each stage involved many different departments which enabled use of cross-functional project teams in parallel. The stage gates were also made cross-functional and the process was expanded to cover the entire idea to product launch with more emphasis on up-front pre-development work. Cooper et al. took a standardized approach for development projects, “game plan”, as a critical success factor (Cooper et al. 1986, p. 84, Cooper et al. 1990, p. 44). Figure below shows a typical second-generation stage-gate-process.

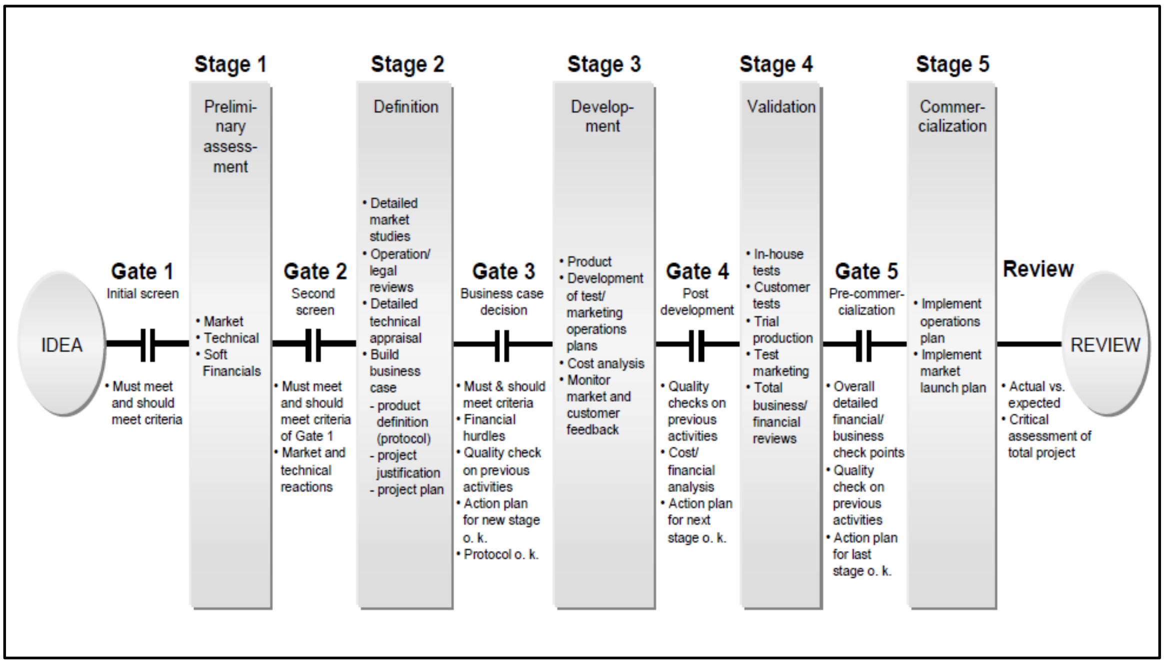


Figure (2.6) Second Generation Stage Gate Process
Source: (Verworn and Herstatt, 2002)

The figure shows an advance version of stage Gate process, where the idea moves from Gate one (initial screening Gate) before passing this Gate the idea shall meet the minimum idea criteria and it pass Stage one, under Stage one Idea is addressed from various aspects such as marketing, technical and financially, then is should be approved by Gate two, here the Idea should go for the second screening Stage where the idea must meet the criteria of the previous gate and also meet the marketing and technical then it moves to Stage two where detailed market studies, detailed operation and legal reviews are carried out, detailed technical appraisal for the business case is made, also product definition such as protocol and project justifications with project plan are produced under this stage, then the stage move to the next step Gate(Gate three), the same the Gate ensure all the previous objectives are met such as initial criteria, financial hurdles and the protocol too, then it moves to Stage three for production, test development plan, cost analysis and monitor market and customer feedback, quality checks for the previous activities and review the action plan for the next step. This moves to Gate approval no 4, where the Gate verify the quality, cost and financial analysis then the action plan for the next stage, then the stage 4 to conduct in-house testing, customers testing, test the market and overall financial and market review conducted under this stage, then moves to Gate five; here overall detailed financial and business check point, quality check points and other verifications are made then it moves to the stage where implement operation and plan the market launch under this stage then go to review for actual launch.

The product development process starts with an idea originating from basic research, seed or unfounded projects, customer-based techniques, and creativity techniques (Cooper et al. 1990, p. 45). At gate 1, the idea is evaluated according to mandatory criteria which have to be satisfied before proceeding to the next stage. Stage 1 assessment is for market, technology, and financials. A second gate, detailed investigations follows during stage 2. Business plan is the output from this stage which is the basis for the decision on business case at gate 3. Actual product and marketing concept is developed in stage 3. Deliverable of this stage is a prototype product. Gate 4 ensures that the developed product meets the defined specifications which were generated at gate 3. In-house product tests, customer field trials, test markets, and trial productions are activities in stage 4. Gate 5 decides on production start-up and market launch, which follow during stage 5. Objective of a terminating review is to compare actual with expected results and assess the entire project (Verworn and Herstatt, 2002).

In Second Generation Stage-gate process the innovation process is broken into discrete stages. This integrates the engineering and marketing perspective. Based on the Go-Kill criteria well defined the Multifunctional teams make decision at the gates. In addition, the stage-gate-process covers the whole innovation process from idea generation to launch. The process is not strictly sequential, parallel activities are permitted to speed up the process (Cooper 1994; Cooper et al. 1990; Verworn and Herstatt, 2002).

But still the second generation stage gate process had its own disadvantages. All products / Projects had to go through mandatory gates. Overlapping of phases was impossible, Project Prioritization and focus was not addressed (Cooper, 1994).

The third generation Stage Gate process was launched with the objective of improving the speeding up the process and more efficient allocation of development resources. Cooper (1994) describes the four Fs which made the third generation stage gate process visibly more efficient which are; Fluidity – It is fluid and adaptable with overlapping or fluid stages, Fuzzy Gates – It represents conditional Go decisions depending on situation, Focused – It builds prioritization methods that look into entire portfolio of projects and focuses resources on best projects, and Flexible – It is not a rigid stage and gate process. Depending on the project stages and gates were customized.

Cooper's Normative Third-Generation Model (1994) is represented by the figure below.

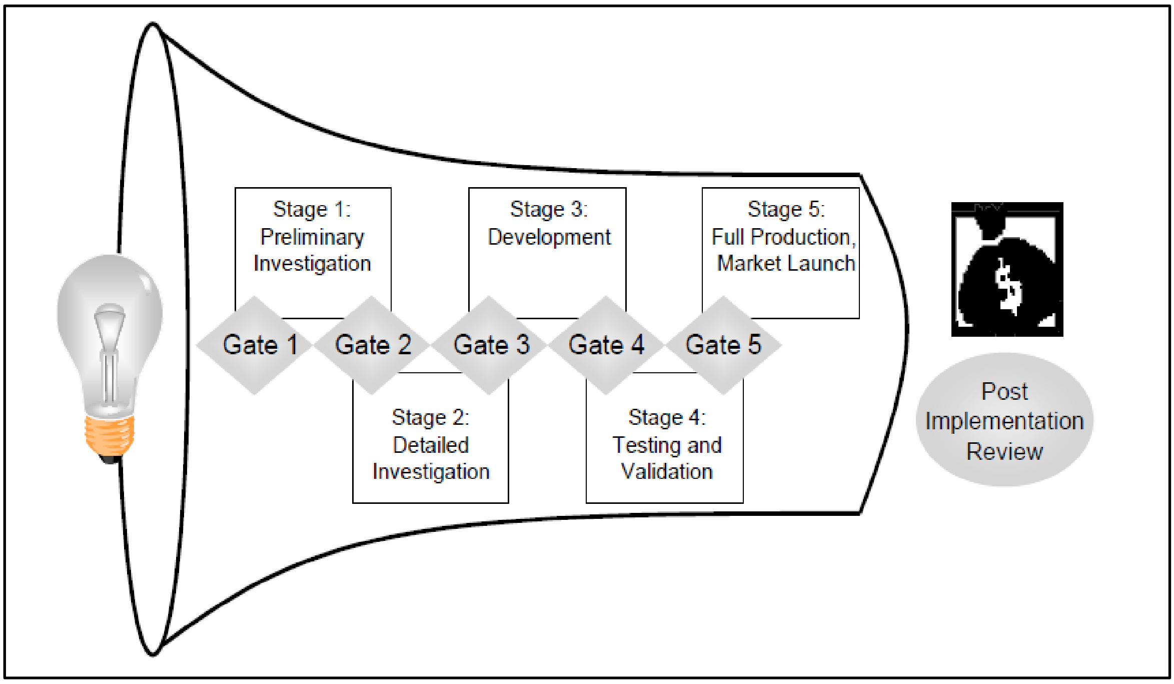


Figure (2.7) Cooper's Third Generation Stage Gate
Source: Cooper, 1996

Third-generation stages and gates are not strictly sequential and less stringent than second-generation stages and gates. They are rather guidelines, than strict rules on how to operate and adapted to the level of risk inherent in a project. To speed up the product development process, transitions between stages are fluent and tasks are to an increasing degree performed in parallel (Cooper, 1996).

Other than developments from Cooper, other management tools were developed. The simultaneous development Phases which is one of such developments has been represented below which is the basis of the Third Generation Stage-gate Model. This model tries to increase the overlap between stages to reduce the schedule (Crawford, 1994).

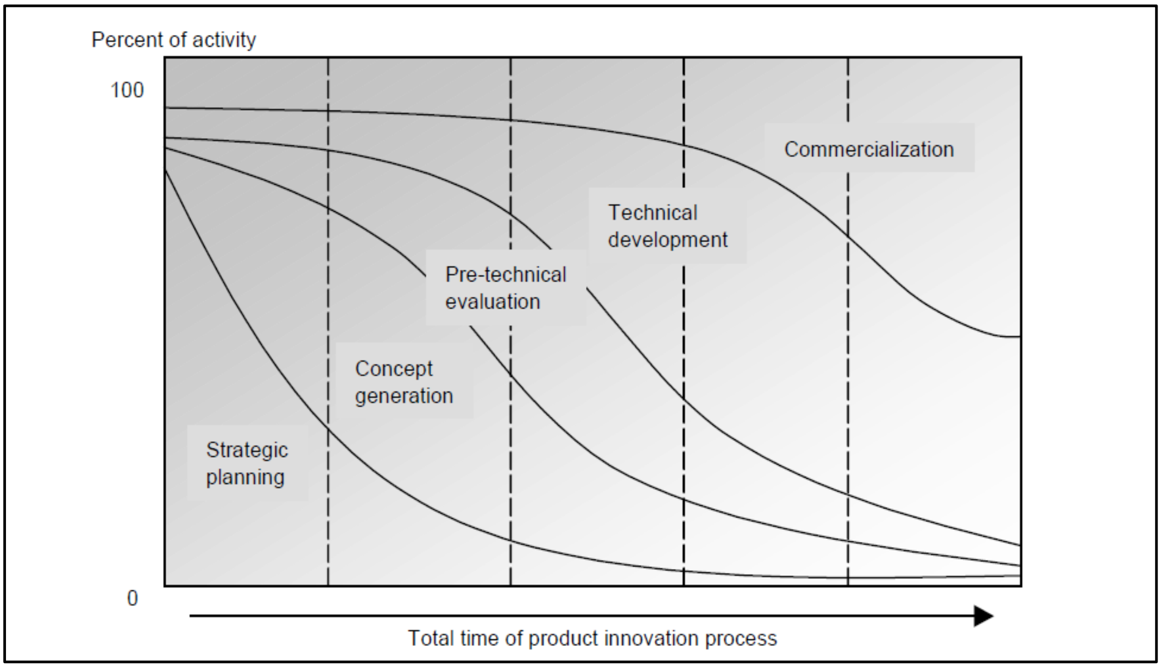


Figure (2.8) Crawford's Third Generation Stage Gate Model
Source: Crawford,1994

A widespread approach used by many well-known companies, including General Motors, Chrysler, Ford, Motorola, Hewlett Packard, and Intel, is called concurrent engineering or integrated product development (Verworn and Herstatt, 2002). Concurrent engineering is defined as “the simultaneous design and development of all the processes and information needed in new product development” (Swink 1998, p. 104). The focus is on improving product manufacturability and quality while reducing development cycle time and cost by resolving product, process, and organizational issues at earlier stages (Deszca et al. 1999, p. 614, Swink 1998, p. 103).

Cooper (2008) defines what are the stages and gates meant to do in the process. As he explains the stages need to have a certain disciplined approach with clear goals. The following things happen in each stage; More information is gathered in comparison to earlier stage & the project uncertainty and risks are to be reduced, Each successive stage costs more than the predecessor stage, which reaffirms the model of incremental commitment. While the cost commitment increases from one stage to other the risk and uncertainties decreases, and Activities in each stage is done in parallel by multifunctional teams.

The following are the key ingredients of the gates; Deliverables on which decisions are made, Criteria against which the project is judged or decisions are made and Outputs in terms of Approval for next stage or as cooper defines Go-Kill-Hold-Recycle decisions are made along with an agreed timeline and resource commitment.

2.5.2. Critical Success Factors for Stage Gate Project Management Process

Cooper (1999) states vital factors which decide the effectiveness of stage gate in his own words (Text quoted as is from Cooper, 1999), Solid up-front homework – to define the Product and justify the project, Voice of the customer / End User – a slave-like dedication to the market and customer/End User inputs throughout the project, Product advantage – differentiated, unique benefits, superior value for the customer, Sharp, stable and early product definition. Before Development begins, A well-planned, adequately-resourced and proficiently-executed launch, Tough go/kill decision points or gates Funnels not tunnels, Accountable, dedicated, supported cross-functional teams with strong leaders and An international orientation international teams, multi-country market research and global or "glocal" products.

Process Description

The figure below shows the Typical Stage Gate phases for Oil & Gas Projects executed by Design-Bid-Build model.

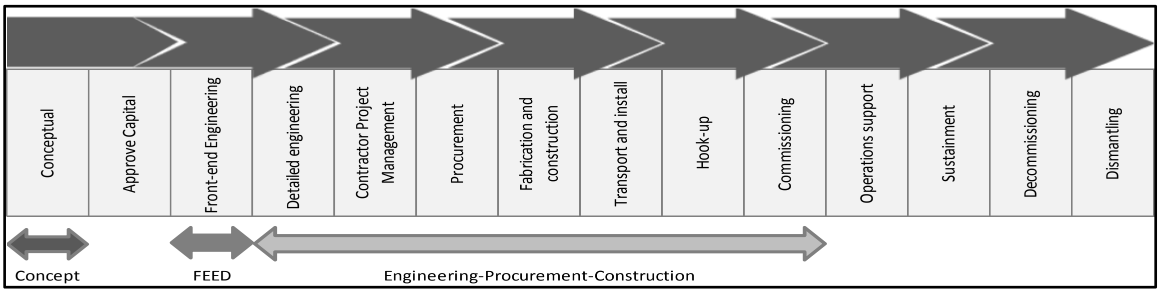


Figure (2.9) Typical Stage Gate Model
Source: (Barton, 2013)

The Project is defined by phases / Stages as follows; Assess Stage, Assess Gate, Conceptual Studies Stage, FEED approval Gate, Front End Engineering Design Stage, EPC tendering approval Gate, Tendering Stage, EPC award Gate, EPC / Execution stage and Handover.

The important point to note in this Project Management Process is that the activities within each of the Stage and gate are overlapping and executed by multidisciplinary teams. This process also allows conditional decisions at the gates to proceed with the next phase thereby allowing a reasonable overlap between stages. The detailed description of the stages and gates follows.

A stakeholder in an organization is any group or individual who can affect or is affected by the achievement of the organization's objectives (Sharp, Finkelstein, & Galal, 1999). Examples of stakeholders are owners (also referred to as clients), government bodies, design consultants (also referred to as FEED consultants), management consultants (also referred to as Project Management Consultant, PMC), construction contractors (also referred to as EPC contactor), subcontractors, main manufactures, sub-manufactures, end users (operation & maintenance), insurers and third party auditors, etc. (Sharp, Finkelstein, & Galal, 1999). There are other stakeholder related to each project depends on the project location and nature and size.

The concept phase is defined as the act of conceiving and planning the structure/ parameter values of a system, device, and process. During the concept the economics, feasibility and project success are studied and evaluated. The initial design phase the Front End Engineering Design (FEED), is the stage of design between concept evaluation and detailed design during which the chosen concept is developed such that most key decisions can be taken. The output of FEED includes an estimate of total installed costs and schedules (ADCO, 2000). Execution/ Build/Construction known as EPC (Engineering, Procurement, and Construction), is a prominent form of contracting agreement in the construction industry. The EPC contractor will carry out further detailed engineering designs, procure all the project equipment and materials as per the specification and data sheets, and then construct to deliver a functioning facility or asset to their clients. The duration, also called EPC phase/stage of the project, is also known as the Execution phase which normally follows FEED (ADCO, 2000). Concept is important if there are other than one option to deliver the project.

Assess Stage is the earliest phase of the project is of Conception where ideas are built and brainstorming is done to gather as many ideas to meet the organizational objective, which can range from debottlenecking existing facilities, development of new fields, upgrading existing facilities, etc.

Assess Gate is where these ideas are assessed and initial assessment is carried out between multi-functional teams on the basis of business feasibility, technical & commercial feasibility and value analysis. The selected Ideas are approved for further conceptual studies. This gate generally considers only a very high level financial feasibility study.

Conceptual Study Stage where the Assess stage is followed by a Conceptual study stage, with duration of between two to four months, also called a feasibility study, where option identification, construction methodology, screening studies, preliminary site investigation, field development plan, process requirements, schedule and budget costs development and select stage all are developed (ADCO, 2000). A Third party consultant is hired for carrying out the conceptual design for the project scenarios. The concept selection stage, with a duration average of between four to eight months, is to develop site investigation, flow schematics, mapping, layouts and geographical information, selection of codes and standards, environmental and social consequences, risk assessments, project costs estimates and overall economics and to define the stage. Technical Options and scenarios are developed and presented in conjunction with the Project HSE Risks, Schedule Risk and Business risk and risk adjusted value for each of the development scenarios are developed.

FEED Approval Gate where following the Conceptual Studies Stage there is a Gate to assess the most feasible scheme for project development based on the Pre-defined criteria for decision. The decision is made at this stage for the most feasible project scenario for further detailed technical studies with Schedule, Risk, HSE criteria, Technical feasibility and economic perspective. The decision at this stage is made for further detailing of one selected scenario for development which requires comparatively larger capital commitment compared to the earlier stage (ADCO, 2000). FEED considered is a gate to approve the project.

Front End Engineering Design Stage is the front-end engineering design stage (FEED), with duration between eight to fourteen months, is dependent on the available details from the owners and the scope details for the construction phase. A FEED consultant develops the project basis of design, process, hydraulic and multiphase flow analysis and operability, process, utility flow, piping and instrumentation diagram, HAZOP, HAZID reviews, schedules and cost estimates together with environmental impact assessments, value engineering, authority liaison, QA and HSE definition in order to finally to produce a FEED design package with EPC (Engineering, Procurement and Construction) scope of work package. At the end of this stage the consultant develops a more detailed economic model with a lesser margin of approximation. Generally, the cost and schedule estimates are much closer to the EPC bidding cost and schedule (ADCO, 2000). FEED is the main design phase and stage.

EPC Tendering Approval Gate where at the end of this stage FEED Stage the decision gate is conducted. During this gate detailed decision criteria are thoroughly assessed. These gate approvals are generally termed as Final

Investment Decision Gate beyond which the capital investment is very large and any change beyond this point on scope of deliverables or Specifications has a severe cost impact on the client. The technical assessment is more stringent to ensure no unknowns are in the EPC Scope of Work which in turn will either lead to contractors adding a huge margin of buffer in the bidding cost or variation orders during execution stage. Decisions are also made regarding the execution strategy for the project. If the development can be done in phases, then the phasing is done by the client and execution packages are split accordingly. Also for Schedule & Cost considerations clients may decide to split the project scope in to different packages and award to more than one contractor who meets the decision criteria.

Tendering Stage is the tendering Phase, which follows the Decision gate, is between 6- 12 months depending on the size of tender and complexity of the work. During this phase the Invitations to Bid are sent out to the contractors, who acknowledge their interest. Thereafter the EPC tender package is provided to the interested EPC Bidders for their evaluation and technical queries are raised by contractors and clarification meetings are held to bridge the gap between the contractor understanding of scope and client requirements. After clarifications are circulated to all the bidders, the bidders submit their technical proposals for client review. During this activity the client, with all stakeholders, reviews the technical proposals and selects the EPC contractor with relevant credentials and technical know-how to submit commercial bids. Commercial bids from contractors are evaluated against the Initial estimates generated during the FEED studies and adjustments are made depending on weather any deviations have been accepted as a part of technical clarification meetings held. At the end of this stage the project has competitive technology.

EPC award Gate is where EPC award Gate follows the tendering phase. During this gate process Client relooks into the bids from contractors for possible differences between the contractors in terms of Execution strategy, Schedule, Contractor capability to mitigate risks identified during FEED stage and Commercial terms. One contractor is selected at the end of this gate and awarded the Contract for Execution of the project (ADCO, 2000). EPC award in other terms is the beginning of construction phase.

EPC / Execution stage is where the EPC stage is also called the execution stage. The contractor will have further detailed engineering and procurement roles in addition to his construction capabilities; the duration varies between 20 to 48 months. Mega projects have more than one design, procurement and execution phases, which is often managed as a programme. During Execution stage, the contractor produces a detailed design, final process and utility flow diagrams, final piping and instrumentation diagrams, civil, mechanical, electrical, control and instrumentation, and telecommunications, specifications good for Procurement and construction. Procurement is divided into Long Lead Items procurement, General Procurement of equipment & packages and Procurement of Bulks. Priorities are set for procurement based on the delivery lead time and Project execution schedule. Also during this phase, the contractor subcontracts certain sections of the work to specialist consultants and sub-contractors who specialize in the work package. The construction activities are executed as per the pre-defined sequence to meet the commissioning targets schedule.

The construction activity is followed Mechanical completion certification by the client. During this process the client verifies the deliverables from the contractor if that meets the specifications approved during the Design Stage of EPC. This process is divided by systems and sub systems and can be done in parallel with commissioning or construction of unrelated systems.

Mechanical Completion Certification is followed by commissioning phase where the various systems constructed or installed which passed client verification through mechanical completion check, are commissioned. During commissioning the systems are lined up with actual working conditions at downstream and upstream battery limits and performance of each system is measured against the designed performance parameters. On successfully meeting the performance parameters the Project is approved by end user and is officially handed over to the end user by the contractor for Operation and regular maintenance as per the maintenance schedule & procedure specified.

2.5.3. Variants of Stage Gate

Several variants of Stage Gate process that have evolved since the early development of this process (Cooper, 1994 and Hauser, Tellis and Griffin, 2005). All models have been developed to overcome one or the other drawback of the process.

stage gate ‘xpress’ and Stage gate ‘lite’ are two such variants. Stage gate ‘xpress’ model is designed for moderate risk projects and stage gate ‘lite’ is designed for small projects. A significant number of organizations have now adopted this approach: skipping stages, overlapping gates, and making conditional decisions (Barczak *et al*., 2009; Simms, 2012). Cooper (2008) has presented a variation, ‘spiral’ development, which incorporates the continual inflow of information, particularly from customers or end users, thereby information is shared by the end users throughout the project development process leading to continuous improvement (Simms, 2012). Stage Gate is being utilized by wide and large organizations to protect their assets and investments

Cooper (2008) presents a leaner model of stage gate. Value stream is connection of all process steps with goal to maximize customer or end use value. In this variant a task force reassess the entire value stream and all non-value activities are removed from the process. All activities, procedures, deliverables and committees are scrutinized in this process (Cooper, 2008). Stage Gate also customized in large organization to further details the stakeholders needs.

2.5.4. Advantages of Stage Gate

Robert Cooper sees the Stage Gate process as a process with number of stages or work stations as a check point for quality control to ensure desired quality prior to moving to next stage. Due to the progressive nature of the stages the cost commitment increases progressively thereby facilitating a better risk management. With gates defined at the end of each stage the owner or Project Executive committee has better control on the project. Cooper has also listed some cases where the Stage Gate model has enhanced the considerable number of successful executions of new product development using Stage Gate philosophy for product development. Cooper also advocates his point that Stage Gate process provides a clearer roadmap to the project leader and project team members on the status of project and how it will proceed to reach its final objective (Cooper, 1990). Stage Gates is widely adopted in the O&G projects.

Mackenzie and Cusworth see one more benefit in Stage Gate process that if in any of the gates the project is found to have deviated from the initial project objective or results of previous stage not satisfactory then the study can return back to the previous phase, thereby mitigating the risk of higher cost impact in case of failure to monitor and measure the project progress and objectives at intervals (Mackenzie and Cusworth, 2007; Wittig, 2013). Stag Gates provide the stakeholder with means to control the project deviation from its original objectives.

Van Der Weijde highlights improved cost predictability, enhanced cost effectiveness, better schedule predictability, faster project deliver (schedule effectiveness), optimised scope, and better operability and safety performance as some of the key benefits of having a phased development process for New product development (Van Der Weijde, 2008; Wittig, 2013). Stage Gate also ensure the cost and schedule are aligned to the project guidelines.

Stage Gate International lists a few more benefits of using Stage Gate process. SGI claims an accelerated Speed of product delivery, better quality of execution and reduced failure rates, better focus and organizational discipline, better resource allocation, better engagement of cross functional teams, and improved co-ordination with external stakeholders as the benefits of Stage Gate process (http://www.stage-gate.com/resources_stage-gate_full.php). Stage Gate considered in the O&G as a value assurance process to ensure quality deliverables are provided.

Ajamian sees the ability to allocate the critical and limited resources to the projects of high importance, ability to foresee business, process and investment issues early, revalidation of technology goals with product / platform strategy, collaboration between the business and technological entities, improved communication and reduced overall cycle time as major advantages of Stage Gate process (Ajamian, 2002). Stage Gate also protect the business execution.

2.5.5. Limitations of Stage Gate

Westney Consulting Group quotes that with many mega projects lately the conventional Stage Gate approach is insufficient to get predictable results from the mega projects and needs better methods. Also it states that the conventional Stage Gate process is good for Small Oil companies which remain competitive due to its capability to take high risk. The same level of Risk may not be acceptable for large companies executing mega projects. The unpredictable nature of Oil & gas pricing trends lately has driven the investors in this sector more cautious and in return the investors demand more clarity on the risks which does not happen with gradual elaboration and linear process (WCG, 2008). Due to the increase in the projects complexity, Stage Gate requires further improvements and revisions.

WCG also states that the linear approach encourages tunneling effect wherein the sources of uncertainty outside the plan is ignored. This tunneling vision is caused due to early cost and schedule estimates before sufficient design detailing is completed. Often the base case is set based on the early estimates. Having an early base case without proper design detailing and assessment has many secondary impacts such as resistance to change from the approved base case and limited interest shown by the stakeholders in exploring alternatives after approval of base case since much of the time and effort has been invested in defining and getting the base case approved and the project team is more focused on the subsequent gates and find reasons to justify the base case rather than reinvesting time and effort on earlier phases (WCG, 2008). Stage Gate also require further development to capture the ignored stakeholders and processes.

Van Der Ven and Cooper see the main disadvantages of Stage Gate models as the delay in project progress for Gate approvals, shifting of focus from the process to the gate approvals hence affecting the overall objective of the project, no overlapping between phases prolongs each stage and process being too bureaucratic (Van Der Ven, 1988: p 112 and Cooper, 1994: p7-8). The focus could be diverted to pass the Gate rather than ensue quality deliverables are provided.

Stage Gate international does not point out any disadvantages of Stage Gate process but highlights a few common errors and fail points. SGI highlights Gates without effective objectives, management or decisions, improper Gatekeeper selection, too much software dependence, bureaucracy and over expectations from Stage Gate process as possible fail points (http://www.stage-gate.com/resources_stage-gate_full.php).

2.6 Introduction to Project Delivery Methods

Project delivery method is a term used to refer to all the contractual relations, roles, and responsibilities of the entities involved in a project. The Associated General Contractors of America (AIA, 2004) defines “project delivery method” as “the comprehensive process of assigning the contractual responsibilities for designing and constructing a project. A delivery method identifies the primary parties taking contractual responsibility for the performance of the work.” Design-Build institute of America defines Project Delivery as “Project Delivery is a comprehensive process including planning, design and construction required to execute and complete a building facility or other type of project”. As Walewski defines it “A project delivery method equates to a procurement approach and defines the relationships, roles and responsibilities of project team members and sequences of activities required to complete a project. A contracting approach is a specific procedure used under the large umbrella of a procurement method to provide techniques for bidding, managing and specifying a project.” (Walewski et al 2001). Thus, different project delivery methods are distinguished by the way the contracts among the owner, the designer, and the builder are formed and the technical relationships among entities within those contracts.

Selection of Project delivery method is done by the organizations giving due consideration to the budget, Schedule, Concept Design, Risk Tolerance & Owner’s expertise and in-house management capability (CMAA, 2012; Ali Touran et. Al, 2009). The findings from a solid experimental study of over 200 major construction projects was that client should focus and consider an overall project delivery strategy when developing the design and construction scope, rather than focus exclusively on the delivery method, (Leicht, R. M., Molenaar, K. R., Messner, J. I., Franz, B. W., and Esmaeili, B. 2015). A research examined typical project execution strategy used an IPD approach as an innovation to reduce inadequacies and disintegration in ventures involving all the stakeholders and the findings were generally support and encourage the IPD structural, climate, and fit elements present in the initial phase of innovation adoption. However, the client did not support the IPD process due to the opted execution strategy “construction management at risk and partnering,” and due to the important changes in the communication behaviors within the project team which did not support the IPD integration, (Sinem Korkmaz, Vernon Miller, and Weida Sun, 2012). A research was conducted to study the idea that design consultant could play major role in design-build contracts and the research found out that the design consultant has a great opportunity to lead and act as a system integrator by broadening their activities, design can reclaim their central position, where both design and management skills can be integrated, based on this research a new concept was developed and two projects were intensively piloted and monitored. It the result was that the developed concept has a lot of advantages for both the client and the design consultant, (Hans Wamelink, Jelle Koolwijk, Alijd van Doorn, 2007). A study was conducted to identify BMI and IPD benefits/deficiencies within the literature, then analysis, and create conceptualizes a new framework to understand the BIM and IPD and their interactions, the result indicated the requirement to have further studies to better understand the relationship between BIM and IPD adoption and project performance measures (such as cost, profit etc.) by utilizing quantitative methods, (Benedict D. Ilozor and David J. Kelly, 2012). A study discussed integrating partnership for decision-making at design stage for major construction projects utilizing IPD and BIM as tools and strategies. The study focused on the challenges and ways to assist in creating a safer, more sustainable environment. As a result, the schedule improved because a concurrent problem-solving approach is adopted rather than a sequential problem-solving approach that has used in the design phase, (Barry Jones, 2014). IPD focus on collaboration and integration which is needed in al kind of projects.

American Institute of Architects (AIA) & Associated General Contractors of America (AGC) have jointly defined the four primary delivery methods broadly covering all the hybrids and tried to arrive at consensus on a set of characteristics for each of the primary delivery methods Viz. Design – Bid – Build (DBB), Construction Management at Risk (CM@R), Design – Build (DB) & Integrated Project Delivery (IPD). This Section will focus on the core / primary characteristics of these four project delivery methods (AIA & AGC, 2011). IPD is a new developed method which requires intensive understanding by the industry.

The Selection of contractors / vendors / specialist service providers is based on Price, Qualification or combination of the two with varying degree of acceptance level.

MacLeamy Curve explain that spending more effort as early as from pre-design, schematics and during the design development has no cost for changes and improvement and has a significant role to impact the cost and also impact the functional capabilities, it is reflect in the red curve. Where the traditional design process starts the design development and construction documents later has major cost on the design changes and low ability to impact the cost (Macleamy, 2004). The curve clearly shows the advantages of early changes ather than late changes in the design.

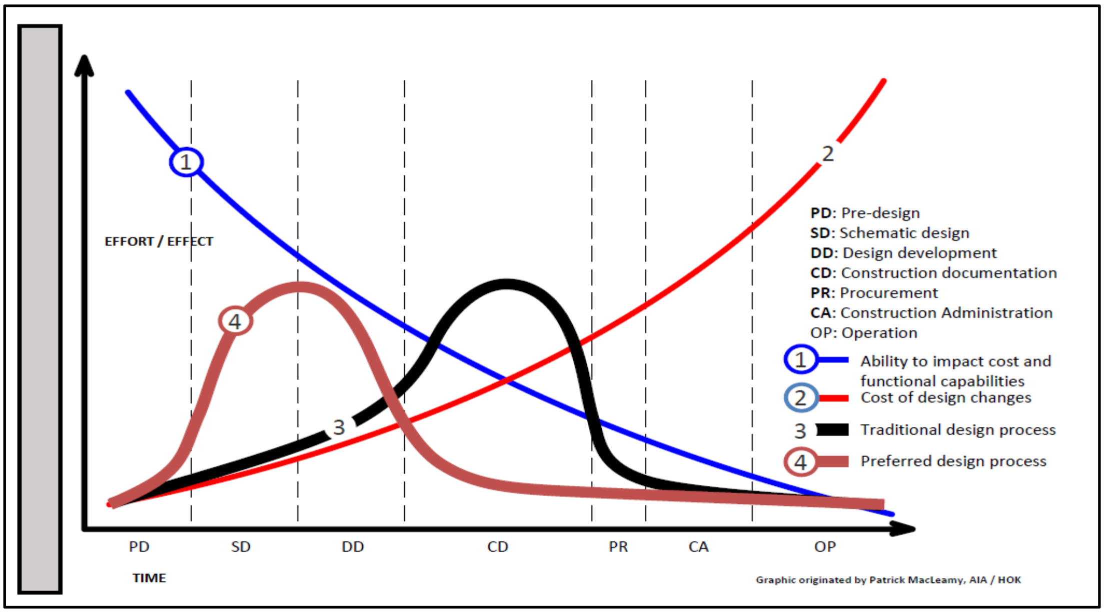


Figure (2.10) Design Build Phases
Source: Patrick Macleamy, http://www.msa-ipd.com/MacleamyCurve.pdf

Where MSA Integrated project delivery, explain Mcleamy curve as Integrated Project Delivery Process, where the 4th curve present design effect that spending time and effort at the conceptualization and design schematic has less cost on design changes and high ability to impact cost and functional capabilities, while under the traditional design process the cost of design changes is very high as far as we move to construction document and increased while moving to construction (MacLeamy, 2004 and Integrated Project Delivery LLC, 2004 and (WP-1202, August, 2004)). IPD explain that its collaboration helps in integrating stakeholders in the early design.

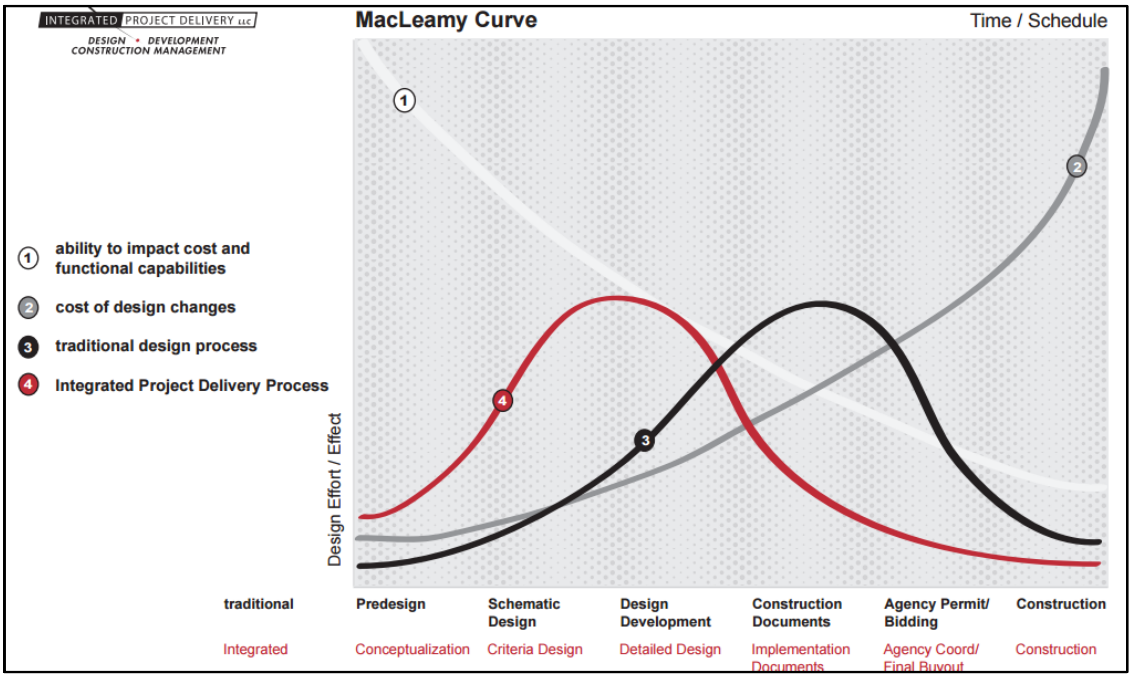


Figure (2.11) Design Build Phases
Source: http://www.msa-ipd.com/MacleamyCurve.pdf

2.7 Design – Build Delivery Method

AIA, 2011 quotes that the main reason for the owner to choose this form of contract over the other is for the reason that the responsibility for design and construction will be with one contractor (AIA, 2011). As Defined by TCRP, (2009) "Design-build is a project delivery method in which the owner procures design and construction services in the same contract from a single legal entity referred to as the design-builder" (TCRP, 2009). As per AIA & AGC, (2011) "In the Design-Build approach to project delivery, the owner contracts with a single entity, the design-build entity, for both design and construction" (AIA & AGC, 2011). Design- Build is not widely used by the O&G industry.

Irrespective of the type of Design-Build contract chosen, all involve three major components. RFQ/RFP is developed by owner, which describes essential project requirements in performance terms. Second, proposals are evaluated. Finally, The owner awards contract for design and construction services to one Design-Build Contractor. (TCRP, 2009). The Design-Build Contractor manages the entire cost of design & construction which is awarded on a fixed price basis by the

Owner. (El Wardani, Messner, and Horman 2006; Ibbs, Kwak and Odabasi 2003; and Graham 2001). Owner could not cover all the aspects before engaging the Contractor which cause major problem in this methods.

Bearup, Kenig, and O'Donnell (2007) state that the defining characteristics of DB are; A single point of responsibility with Design-Build Contractor, (Bearup, Kenig, and O'Donnell, 2007), A schedule that allows for overlapping design and construction, (Bearup, Kenig, and O'Donnell, 2007), A design-builder that furnishes preconstruction services during the project design, and (Bearup, Kenig, and O'Donnell, 2007), An owner that expects the design-builder to provide a firm, fixed price and to commit to a delivery schedule. (Bearup, Kenig, and O'Donnell, 2007), Qualifications Based Selection, Best Value: Fees or Total Project Cost, or Low Bid. (AIA & AGC, 2011), and Overall project planning and scheduling by the design-build entity prior to mobilization (made possible by the single point of responsibility) (AIA& AGC, 2011).

Figure below shows that from the owner's perspective, this contract type simplifies Owner's responsibilities. In Design-Build contracting the owner holds no responsibility for the design phase hence the relation with the Design-Build Contractor is of Mutual Trust (Beard, Loulakis, and Wundram 2001). Compared to other Project Delivery methods the Design-Build contractor has more control on the project in this contracting type hence the execution is comparatively faster (SAIC, AECOM Consult, and University of Colorado at Boulder 2006). The DB is good method is owner has clear definition and scope.

The ability to choose contractors for design is not competitive since one entity is chosen by the owner to execute both design and construction. There is a high level of uncertainty about the overall project cost and schedule estimates since the project is awarded before design information is available. This leave a high level of uncertainty in the final cost of the project and the resulting implications due to huge variations from the budgeted and contract award price (TCRP, 2009) ,this type also does not provide best cost model.

Design-build-operate-transfer, design-build-operate-own (sometimes called lease-back), and DBOM, are the common variants of this contracting strategy, where the contractor's services are extended beyond the construction phase of the project (Wiss, Roberts, and Phraner 2000; Kessler 2005). Extending the contractor scope is practical for long term agreements.

The below figure shows a typical Stakeholder responsibility and Project Phasing for Design-Build Project Delivery method.

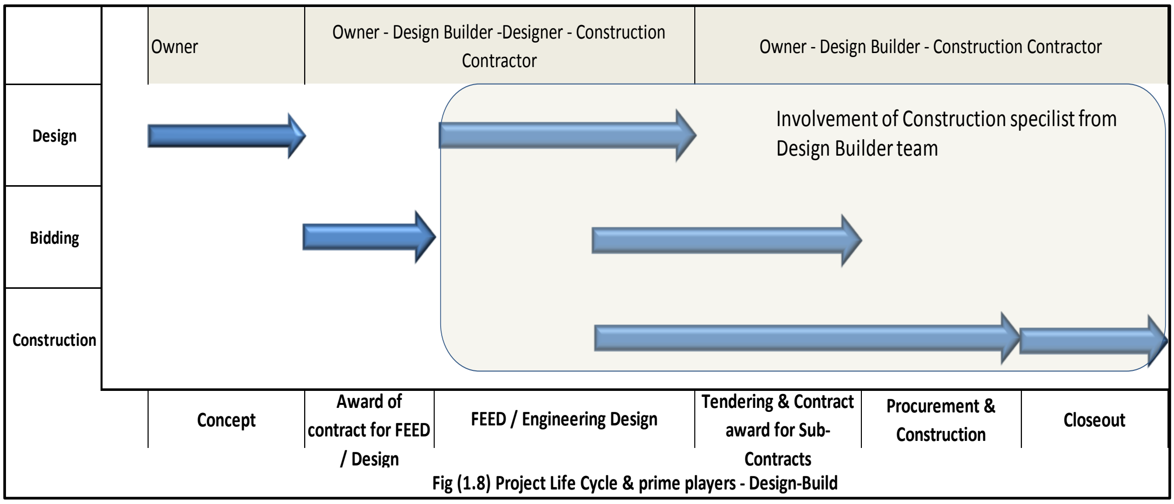


Figure (2.12) Design Build Phases
Source: ADNOC group of companies, 2010.

The above schedule explains the sequence and process of Oil & Gas milestones and activities. This began by the client initiate the idea or the conceptualized statement of requirement; this is mostly executed by the owner himself and sometime is prepared by a high level consultant. Then the owner bid or select the designer and the contractor as single entity to provide a detailed engineering design and then began the construction.

Figure below shows a typical communication network and contracts between various entities. From the below diagram the design phase communication and contract is made between two parties; owner and the design-build contractor, since there is a single entity to design and then build, there is a single contract and only communication is variable, since the design build contractor may separate the designing team from the construction team.

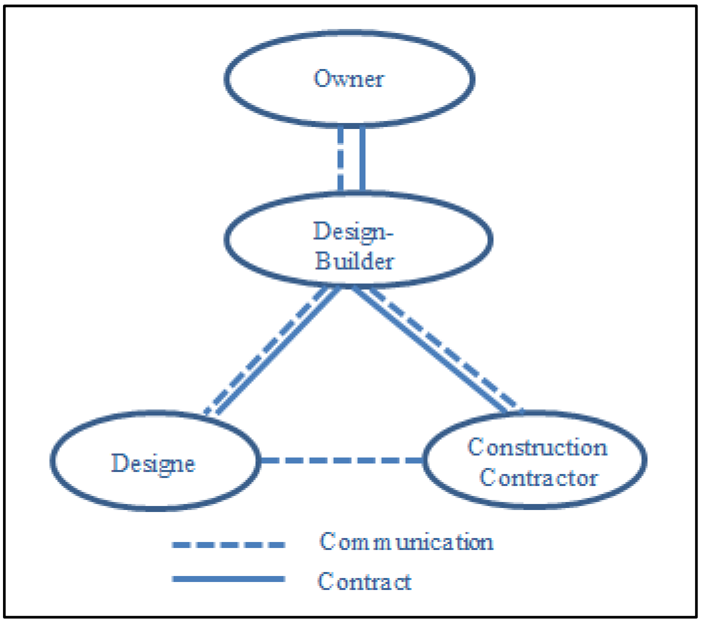


Figure (2.13) Design Build Communication & Contract between stakeholders
(Adapted from American institute of Architects 1996)

2.7.1 Advantages of Design Build

Gary Cudney in his article for International parking institute briefly discusses the advantages and disadvantages of Design build Project delivery Model. Design Build model gives the owner authorizes a single point responsible Design Build contractor to control the project through from Design to Construction. (Cudney, 2006; TCS, 2007) Cudney also puts forth that Design Build model can encourage better co-ordination between Design & Construction teams since the same contractor will be responsible for both the phases. Dispute between Design Consultant and contractor is minimum and any error of omission is DB Contractor’s responsibility. DB model is typically suitable for Owners who are risk averse and the costs are well defined earlier and since contractor is involved from early design stage the schedule is much accelerated compared to Design Bid Build Model for execution (Cudney, 2006; TCS, 2007). There are other advantages of DB which are not mentioned in the literature.

David Molda, in his article for Finance & Commerce lists potential to attract specialized professional services for the project, Shorter project timeframe and earlier project output, Single source responsibility and warranty as the major driving factors for choosing Design Build model over other models of project delivery. (Molda, 2009). Partnering could be one of the reasons to opt for DB approach.

CMAA (2012) affirms the benefits listed by Cudney's reasons for using Design Build models for project delivery. CMAA states Quicker project delivery as compared to traditional Design Bid Build model, Single point accountability for project design and construction phases, better involvement of construction entity early during design thereby improving the cost efficiency of the project with lesser unknowns for construction phase and change orders restricted only to Owner initiated changes gives Design build model an edge over traditional delivery method. (CMAA 2012). Friedlander (2015) advocates for Design Build for reasons such as faster project completion, Single point responsibility for design and construction phases, earlier cost certainty, better communication and fewer disputes compared to other traditional Models of project delivery (Friedlander, 2015). Emphasis on cost control and lesser Owner Interference and expertise are few advantages noted by Maurice R. Masucci as advantages of DB Delivery method (Masucci, 2008). Possible innovation and improvements since Construction methods can be chosen to match contractor capabilities (TCS, 2007). DB considered as faster compared to DBB since is eliminates the bidding durations.

2.7.2 Disadvantages of Design Build Project

Gary Cudney in his article touches upon the various disadvantages of Design Build project delivery method. As per Cudney in Design Build model the contractor is more incentivized for completing the project faster and less expensive so it has an adverse impact on the quality of deliverables. The owner has less control over the design consultant since the project is only supervised by owner but actually controlled by the Design build contractor. Owner has to also take the responsibility of going into the details of describing the objectives, specifications, goals, etc. very early in the project and any missed item will leave the front open for claims from the design build contractor. This risk is so high that it nearly overruns all the benefit of choosing the design build contract for project (Cudney, 2006). DB considered as one of the reasons behind poor quality of deliverables.

Areas of concerns have also been highlighted for this delivery method by CMAA in their publication Owner's Guide to project delivery methods such as less control of owner and other stakeholders in the project after nominating Design Build contractor, high response required from owner to make advantage of the project delivery model, less benefits passed on to owner on account of design optimization, less flexible where design approvals are required from multiple stakeholders and not appropriate for non-standard technologically complex projects which require owner and stakeholder and specialist inputs during design and construction phases to meet a progressively detailed design requirement from owner (CMAA, 2012). DB does not provide the owner with power and all the problems are hided.

From the owner's view it is difficult to compare the various designs of the Design build contractors submitted during bidding of contract. And the basis of comparison of the bids will not be uniform since the owner's objectives can be met by more than one method or choice of design. Also the DB model does not assure the least cost for the project since the award for DB is mainly through qualification of contractor and negotiations and not through competitive bidding since very les information is available so early in the project. DB contracts also face a probable situation where the contractor miscalculated the project cost and is incapable of delivering his contractual obligations due to cost overrun. This can cause irreparable damage in terms of cost and schedule delays to the project (Shapiro, 2013). DB also does not provide single design to choose, i.e. each contractor could provide his own design and no clear commercial comparison could be achieved.

Masucci refers to comprehensive performance specification requirements from Owner, Possible design changes after Construction start being very expensive, Conflict of interest between designer and DB Contractor, Owner’s interest not represented by Main players of the project such as the designer and DB Contractor, Restrictions due to local or organizational regulations as few of the major disadvantages of DB model of Project delivery (Masucci, 2008). Further references were found on Design Build model where it is cited that it is difficult to set the selection criteria for the DB Contractor due to lack of available project design information. Quality control is role of the DB Contractor hence there are chances of compromise on quality to make the project more profitable. Since selection of the Designer is responsibility of the DB Contractor, cost will take precedence over the quality of designer. (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf; Fernane, 2011). Less Opportunity for smaller and local construction companies. Competition is less hence cannot assure best price for the project. Cash flows have to be higher compared to traditional delivery methods to meet the accelerated and parallel project activities (TCS, 2007). DB also considered for very large projects and can be only sued on this scale and size.

2.8 Construction Manager at Risk Delivery Method

“CMR projects are characterized by a contract between an owner and a construction manager who will be at risk for the final cost and time of construction.” (TCRP, 2009) In this agreement, a Construction Manager authorized by the Owner provides his inputs during the design phase and manages the construction phase of the project for the Owner. The purpose of this type of Contract is to encourage professional support for executing the project when the Owner’s organization does not have the required level of expertise (North Carolina State Construction Office 2005). Typically, the CMR contracts are fixed price contracts between the owner & the construction Manager with clause for incentive. Typically, the Owner manages the design and provides the construction Manager with the whole set of approved documents to enable him to manage the construction phase of the project. According to AGC (2004), the defining characteristics of the CMR are; The designer and the CMR hold separate contracts with the owner and The CMR is chosen on the basis of criteria other than just the lowest construction cost, such as qualifications and past performance.

According to Bearup, Kenig, and O'Donnell (2007), additional defining characteristics are; The CMR contracts directly with trades and takes on "performance risk" (cost and schedule commitments), The schedule allows for overlapping design and construction, The owner procures preconstruction services from the CMR; and The owner expects the CMR to provide GMP and to commit to a delivery schedule.

A final defining characteristic, noted in AIA's "Construction Manager at-Risk State Statute Compendium," is that "transparency is enhanced, because all costs and fees are in the open, which diminishes adversarial relationships between components working on the project, while at the same time eliminating bid shopping" (AIA 2005, p. 1). This method require additional resources to control the project from the Construction Manager side and less from the owner side.

The reasons for Owners to adopt CMR strategy is mainly for construction expertise with the construction Manager and projects executed are faster (3D/International, Inc. 2005). Inputs from Construction Manager during the design Phase improves the quality of the engineering which considers constructability aspects during design. In this project delivery method, the Construction Management Agency has a high risk of signing a contract agreement on a fixed price basis with owner during the early Phases of the project (TCRP, 2009). The level of accuracy for cost estimated early in the project is comparatively better.

One advantage of this delivery method over Design-Build is that the competitive bidding for design phase and construction phase is independent which will give the flexibility to choose design consultant separately based on their capability (AIA 2005). Figure below shows the typical CMR phase and stakeholder engagement.

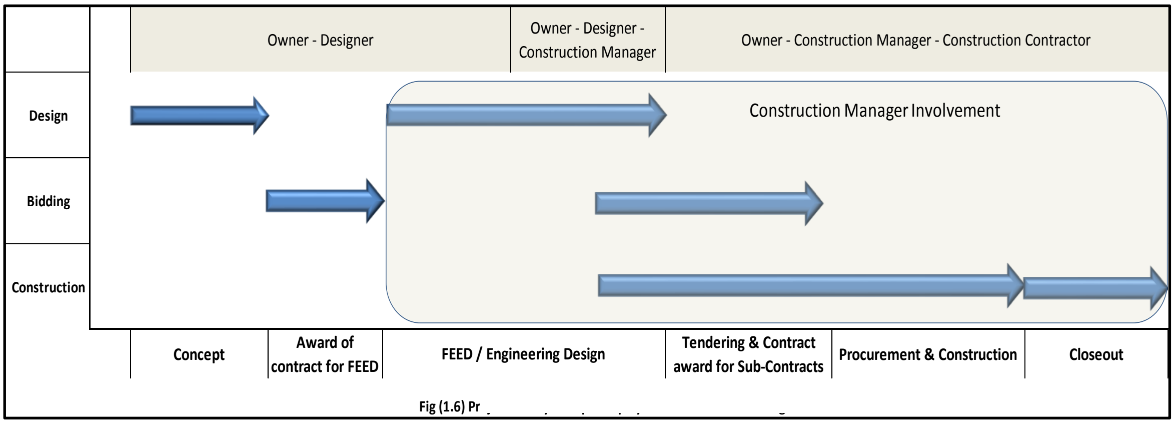


Figure (2.14) Construction Manager at Risk Phases
Source: ADNOC group of companies, 2010.

The above schedule show that the owner starts the project with designing consultant and this has in most of the cases three stages; concept stage, FEED stage and then detailed engineering design stage. Then the project moves to construction phase with various stages, such as execute the detailed engineering, tendering and award the sub-construction scopes, procurement and construction and then close out the project.

The term “at-risk” refers to the fact that the contractor holds the trade contracts and takes the performance risk for construction (AIA & AGC, 2011). The defining characteristics identify CMR (Adapted from AIA & AGC, 2011) as, Three prime players—owner, architect, CMR, Two separate contracts—owner to architect, owner to CMR and Final provider selection based on Qualifications Based Selection or Best Value. Typical characteristics of the CMR approach include (Adapted from AIA & AGC, 2011); Hiring of the Construction Manager during the design phase, Clear quality standards produced by the contract’s prescriptive specifications and Establishment of a guaranteed maximum price. Other characteristics that may be seen in the CMR approach include the following (Adapted from AIA & AGC, 2011). As Overlapping phases—design and build which is preconstruction services offered by the architect, CM or contractor (such as constructability review, bid climate, and bid management).

CMR delivery model is represented in the figure below.

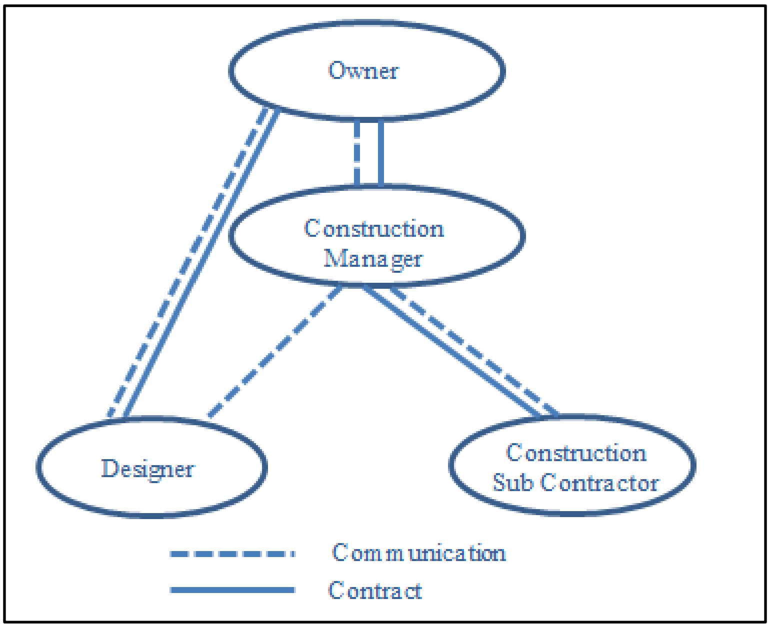


Figure (2.15) Construction Manager at Risk- Communication and Contracts between Stakeholders
(Adapted from American institute of Architects 1996)

The diagram above shows that the owner has more than one contract and communication links; one with the construction manager and one with the designer, then the contracts and communication moves from the owner side to the construction manager with designer in the communication and expanded to cover communication and contract with subcontractors.

2.8.1 Advantages of Construction Manager at Risk

CMAA (2012) highlights two striking advantages of CMAR form of project delivery; one is that the construction experience and lessons learned from the same is included while preparing the design and the second is that the construction phase of the project can start before the completion of design which assists in fast tracking the projects (CMAA, 2012). There are other advantages which could be driven by the main advantages. Masucci highlights transfer of risk from Owner to CM is the advantage during the construction phase of the project. Without the event of changes included to the scope by Owner, the Construction cost is fairly fixed with no escalations. CM has the total control over the Sub-contractors hence schedule committed by CM is his responsibility (Masucci, 2008). Is the scope is well define then this approach could minimize the cost impact.

Selection of CM and the Design consultant is under the Owner’s control hence is based on the qualification for the job. Since the CM is in control over the project design and construction phase, considerable construction activity can be overlapped with the design phase, hence the project can be fast-tracked. Involvement of CM at the cost and schedule estimation stage adds a more accuracy to the process. All work other than CM and Design consultant is selected on a least price basis thereby optimizing the quality and cost with this delivery method. This delivery method also allows a cost sharing model thereby alignment of project objectives between the Owner & CM encourages high quality with least cost. (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf)

Utilization of factors other than least cost for Contractor selection, increased collaboration & traditional relationship with design consultant are seen as main advantages by Johnson & Zeltner (Johnson & Zeltner, 2012). CM is incentivized by implementing GMP with fixed fee and sharing percentage of the savings further by the CM (TCS, 2007). Design and execution parties are collaborated in this method.

CMAR allows constructability Operability and maintenance considerations to be built in the design. Overall project risk is considerably less compared to traditional project delivery (DBB) since pre-construction services are separately managed by an experience and qualified CM. Design misunderstandings and omissions can be avoided, in turn the change orders during construction is minimum. Higher control possible from Owner on the cost, schedule & quality (Salerno & Holmes, 2015). He risk also considered less compared or other methods.

2.8.2 Disadvantages of Construction Manager at Risk

Construction Management entity selection is a critical process since it has to be more based on qualification to handle similar projects in the past and not least cost basis. Construction management entity will hold the risk during the construction phase of the project, hence the advice from Construction management entity will be biased during the construction phase since the risk is entirely held by the CM. (CMAA, 2012). Masucci highlights that reduced owner control during construction, design changes after start of construction being very expensive and conflict of interest between CM and Construction Contractor as possible concerns of CMAR project delivery method (Maurice, 2008). The main challenge is to select the right CM.

Since the design consultant is under Owner's control, CM's inputs to design may be overlooked. Price competition may be limited and driven more by risk and quality perspectives for the project. (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf).

Incentive sharing with CM may inflate the initial GMP budget. Large contingencies may be added if GMP approach is adopted for CMAR project delivery (TCS, 2007). Accountability for the different entities and phases keeps shifting from Owner to CM. Owner has to have individual contracts for Design Consultant & CM which is a cumbersome process. CM contract is signed before design is completed, hence the cost of construction has high level of approximation and probability to change (Johnson & Zeltner, 2012). CM is selected before the detailed cost estimates are developed. Owner owns the design so any change orders arising out of incomplete or improper design is Owner's responsibility and can lead to change orders. Pre-construction services are an added cost and the cost commitment is made prior to the start of actual construction activity. Communication gaps and conflicts between design consultant and CM can impact the project. Design phase requires high involvement and staff mobilization from Owner. Reduced control from Owner during construction can slow down the project (Salerno & Holmes, 2015). The incentive will play major role in this type of projects.

2.9 Design-Bid-Build Delivery Method

This method involves three Stakeholders in the project delivery process—owner, designer, and Construction Contractor—in traditionally separate contracts. "Traditional" is frequently used to describe the Design-Bid-Build method. Under this type of contract separate contracts are signed between Owner & Designer and Owner & construction contractor. (AIA & AGC, 2011) In this type of contract the Owner owns the design generated by the designer which in turn is provided to the successful Construction contractor. Hence the design errors are responsibilities of the Owner. All Phases of the project is aligned in a linear fashion (TCRP, 2009). Figure below represents the phases of the project following Design-Bid-Build model and the stakeholder involvement at different phases.

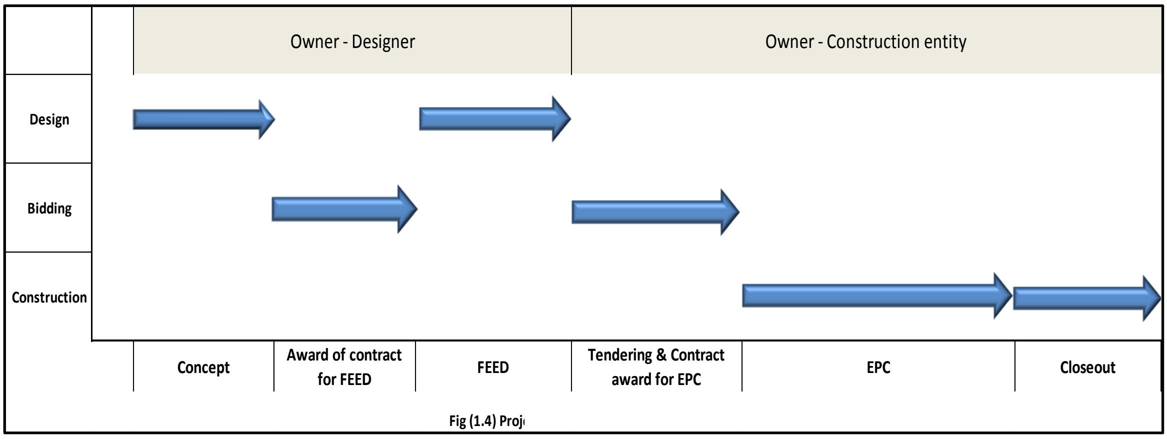


Figure (2.16) Design Bid Build Phases
Source: ADNOC group of companies, 2010.

The above schedule shows a typical and most likely schedule between the project key stakeholders. The owner and designer phase, where three stages are encountered, such as concept, then award FEED, execute the FEED. Owner start tendering and contracting the EPC and this delink the designer from the post phases of the project and the contractor start the upcoming phases.

The process in this type of contracts is that the Owner awards the design to a designer and manages the design. Then the design documents are used for tendering, which in turn is bid by a successful Construction Contractor, who executes the construction phase again under the management of the owner. In this contract type the owner has comparable risk on the schedule & design inaccuracies or omissions. Both the design and construction contracts are awarded to the lowest bidder. In some cases, the owner decides to award the contract based on technical qualifications or past experience of designer and construction contractor (AIA & AGC, 2011).

The following defining characteristics identify Design-Bid-Build (Adapted from AIA & AGC, 2011); Three prime players—owner, designer, contractor, Two separate contracts—owner-designer, owner-contractor and Final contractor selection is based on Low Bid or Best Value: Total Cost.

Typical characteristics of the Design-Bid-Build approach include the following (Adapted from AIA & AGC, 2011); Three phases—design, bid, build. These phases may be linear or overlapping if a project is fast tracked or bid-out to multiple prime contractors, Well-established and broadly documented roles, Contract documents that are typically completed in a single package before construction begins, requiring construction-related decisions in advance of actual execution, Construction planning based on completed documents, Complete specifications that produce clear quality standards and Configuration and details of finished product agreed to by all parties before construction begins.

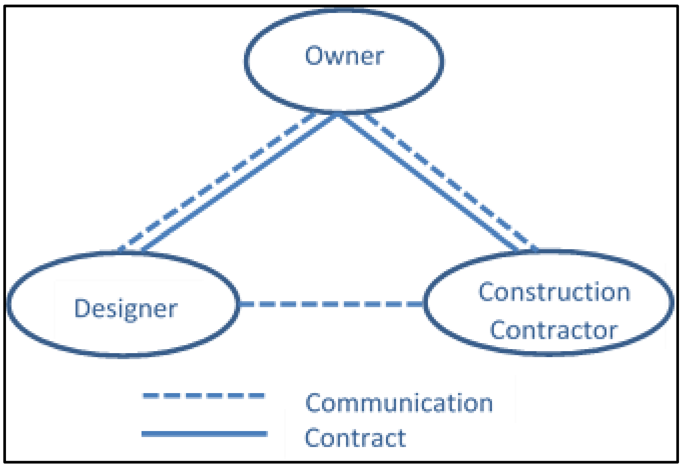


Figure (2.17) Design Bid Build Communication and Contracts between Stakeholders
Source: (Adapted from American institute of Architects 1996).

The communication in this strategy as shown in the above diagram is where the owner has two communication and contracting channels and he is between the designer and the construction contractor. There is no contracting channel between the designer and the construction contractor and only limited communication channel may exist.

2.9.1 Advantages of Design-Bid-Build

In Design Bid Build model for Project Delivery Owner has the control over the design and construction phases of the project which is contrary to the Design Build model. Design is completed before major construction works so the cost of rework is comparatively less. Also design changes are incorporated with less resistance in this delivery method. Construction contractors are chosen based on the qualification and cost and the bids are more competitive since considerable design information is made available before biffing for construction starts. This model follows linear process so easier to control and better quality output is achieved in the project (Masucci, 2008; TCS, 2007). CMAA refers to this contract as a traditional contracting method which has distinctive benefits such as; this delivery method is widely used and tested with assured results and the owner has good control over the end product (CMAA, 2012; Fernane, 2011; TCS, 2007). This approach provide the owner with more control in the design and cost.

Design Consultant is hired by owner which gives owner control on defining owner's and End user's requirements properly during the design stage. The design consultant works independently under the contract with Owner to produce unbiased cost and schedule estimates. Also the responsibility of the design and estimates is with the design consultant which is open for verification by client. DBB Model helps secure better bids during design and construction phase since the selected consultants / contractor has to meet both the Owner's Qualification requirements and has to win the project through competitive bidding. Design Bid Build is one of the most widely used Project delivery method which assists the working teams and organizations and saves the time required for educating the teams. (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf; TCS, 2007)

2.9.2 Disadvantages of Design-Bid-Build

The major concerns highlighted in literature are related to the long process which has a schedule impact on the project. Fast-tracking initiatives cannot help overlapping the activities in different phases since the responsibility transfer happens contractually from one party to another at the end of the phase. Since the DBB model encourages the owner to pursue with the least cost based award, this may discourage right skilled or qualified bidders and ultimately contract may be awarded on least cost and not qualification of bidders. Sub-contractors are purely selected by the contractors and that will again affect the quality of work delivered by them since contractors will look for cheapest way to deliver the project. Owner takes the entire risk since he owns the design from the design consultant and awards the construction to the construction contractor. Any missed information in the design or errors will lead to variations and change orders. Cost saving and design optimization during construction is not possible due to contractual limitations. Any cost saving initiative from contractor will be seen as a scope reduction by client and vice versa. Low Cost approach by Contractors during execution needs to be compensated with additional inspection. Greatest potential for cost/time growth (in comparison to other delivery methods). (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf; TCS, 2007)

Owner expertise is required to thoroughly study the design and take ownership of design before construction contract award. Also the Owner team size will be considerably bigger for managing the Contractor and design teams. Contractor inputs is not captured during the design since the construction contractor is involved after the initial design is completed (TCS, 2007; Fernane, 2011; Masucci, 2008). CMAA (2012) highlights that the design consultant may have limitations to visualize the final constructed product which will often lead to many unknowns in the designs and the design will have much higher allowances for cost and schedule. The final objectives of Design Consultant, Construction contractor and Owner are not aligned. Where the design consultant and construction contractor are incentivized by cutting the quality and schedule Owner is more focused on quality of deliverables. This misalignment often leads to change orders, project delays and compromise of quality (CMAA, 2012; TCS, 2007). Owner additional resources and engineers involvement is key success for this type of method.

2.10 Collaborative Project Delivery Methods

Cheung (2010) lists the six major types of relational and collaborative contracting methods; Strategic Partnering (Lu and Yan, 2007), Project Alliance, Strategic

Alliance (Cheng et al., 2004), Public-Private partnership (Tang et al., 2010) and Joint Venture (Walker and Johannes, 2003; Daniel et. al, 2014).

This section will focus on the predominant forms of project delivery; Partnering and Alliancing.

2.10.1 Partnering Strategy

Chris Skeggs defines partnering as a co-operative relationship between business partners formed in order to improve performance in the delivery of projects (Skeggs, 2001). Due to different perceptions and definitions available in literature it could be concluded that the generic views of partnering common in most of the literature can be summarized as; Partnering is a collaborative process and not a simple relationship, Partnering is co-operation between the organizations with common project goals to increase the project efficiency by sharing resources and having open communication, Partnering can be implemented between organizations to achieve Long term objectives called as strategic Partnering or can be implemented for a specific project, known as Project Partnering. (Skeggs, 2001).

Travis R. Johnson, in his Thesis mentions that the objective of Partnering is to move from non-interference based execution models to more collaborative approach with mutual benefits (Travis, 2011). As Chan puts it Partnering agreement is a non-contractual but formally structured charter in which each party promises to act in the best interest of the project and the project team (Chan et al., 2001). This approach address the collaboration with limited responsibilities for each partner.

2.10.2 Alliancing Strategy

Alliancing is mainly prevalent in Australian Construction industry. Alliancing is a form of collaborative techniques of project management (Peter Raisbeck et. Al, 2010). Alliancing Contracting was developed for high risk Oil and Gas projects in early 1990s. Basically Alliancing for of contract allows a more collaborative working environment and sharing of project risk amongst the stakeholders. (Peter

Raisbeck et. Al, 2010). It is mandatory to have a Multi-Party contract for Project Alliancing (Daniel et. Al, 2014). The basic principles of general alliancing are; Joint agreement and joint organization (DTF, 2006; Jefferies et al., 2006; Lahdenperä, 2011), Joint decision-making and problem-solving (DTF, 2006; DIT, 2011), Open-book and communication (DTF, 2006; Jefferies et al., 2006; DIT, 2011), Team-building: meetings and workshops (Jefferies et al., 2006; Yeung et al., 2007; Bresnen et al., 2010) and Monitoring performance and job satisfaction (DTF, 2006; Jefferies et al., 2006).

Mistry and Davis describe Alliancing as a cooperative arrangement between two or more organizations working towards achieving common goals and objectives for a project (Mistry and Davis, 2009). Alliancing also encourages selection of Alliance consortium based on performance rather than through competitive pricing alone. (Hampson and Walker 2003: 63). Similar to Integrated Project Development, in Alliancing, the Construction Contractor is brought in from first day of the project (Raisbeck et. al, 2010). In other way of describing, Jim Ross explains Project Alliancing as a contract type where the Owner, Contractor and other service providers work as an integrated team to deliver a project under a contractual framework with aligned commercial interests with project outcomes (Ross, 2003).

2.10.3 Difference between Alliancing and Partnering

Alliancing is different from the Project Partnering where the individual stakeholder still holds their individual identity which is contrary to the project alliancing where they merge to form one project team (Walker & Hampson, 2003). Also in partnering the individual stakeholder has their own risks and rewards defined unlike alliancing where the risk and rewards are aligned for all alliance partners (Walker & Hampson, 2003).

Travis R. Johnson in his Thesis highlights the prime difference between the Alliancing and Partnering models are; Organization: While alliancing mandates a Project contract Partnering works on a non-contractual Partnering agreement (Travis, 2011), Relationships: Where Partnering works on Trust and relationship building and dispute resolution through non-contractual procedures Alliancing operates on principles of joint decision making where the Owner has no more authority than the contractor who is an alliancing partner (Travis, 2011), Risk: Partnering follows a division of liability and fault based claims whereas under alliancing there is a waiver of consequential damages on all parties and the liability is shared (Travis, 2011) and Performance: Goals are set mutually (non-contractual) and performance is measured for individual stake holding organizations in case of partnering whereas in alliancing the risk and rewards are shared contractually between the stake holding organizations (Travis, 2011).

2.11 Integrated Project Delivery (IPD)

2.11.1 Introduction

Integrated Project Delivery (IPD) is a more recent development in the field of project delivery. (AIA & AGC, 2011) IPD is based on a collaborative process in which the teams are engaged with their best expertise in the early design phase of the project. The involvement of experts from all disciplines ensures the design meets the highest quality standards (AIA 2007; AIA California Council, 2008; AGC, 2009). As per KPMG IPD is extremely beneficial for mega projects with technical complexity and very challenging schedule targets (KPMG, 2013). AIA California Council, (2007) defines Integrated Project Delivery (IPD) as "a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction." (AIA California Council, 2007). IPD encourages knowledge sharing and expertise involvement during the entire project from all the team members (AIA, 2007) AIA (2010). Differentiates IPD from Lean Construction quoting that Lean Construction is a tool which supports IPD and is a subset of the IPD process and not the process itself. (AIA California Council, 2010). In the owners' perspective the IPD contract execution does need a higher level of collaboration and inputs but does not need any additional resources (AIA California Council, 2010).

Project Delivery (AIA & AGC, 2011) is a method for assigning responsibility to an organization or an individual for providing design and construction services. Integrated Project Delivery (IPD) (AIA, 2007) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. Mega Projects (EY, 2014) is projects with a proposed capital investment above US$1b.

The Characteristics differentiate IPD from traditional contracts are; Multi-Party Contracts, Early Involvement of Key Participants, Collaborative Decision making and control, Shared risk and rewards, Liability waivers among key participants and Jointly developed project goals.

All the above characteristics need to be incorporated to realize IPD in its purest form (Sive, 2009). An IPD Project as described by KPMG (2013) may require more involvement from senior members of the project and may have a higher initial investment but if executed properly can give back a greater value (KPMG, 2013). AIA has devised a phase wise check list for implementing IPD to gain maximum benefit from it (AIA California Council, 2007). Conceptualization is where various steps are involved in this early phase such as; Early Stakeholder engagement, Identification of key technologies and key parameters, Early development of cost structure, Performance metrics with proper goals are set, Incentives to be defined with proper metrics and preliminary schedule is developed in conjunction with developing model.

Criteria Design is where during the criteria design Phase the following steps are involved: Design decisions are made which are best for project, Visualization of project model is linked to cost model, Owner sign off on agreement with scope and Price fixed allowing the team to optimize designs, Update preliminary schedule. Earlier recognition of inadequate performance and Agreement on tolerances between various disciplines.

Detailed Design where the following steps are involved in detailed Design are : The design intent is fully defined and validated at the end of this phase with no ambiguity, The design phase is longer due to more detailed design capturing detail information from all stakeholders, All major Systems are defined, By the end of integrated design all components of project are well defined and all conflicts are resolved, Subcontractor and vendor inputs are integrated with the design and Specifications are developed based on the agreed systems and codes.

Implementation documents during implementation document development stage the following steps are achieved: All Shop drawings, vendor drawings etc. are integrated with the project drawings & Specifications, At the beginning of implementation document phase entire project and systems are identified, The goal of this phase is to identify the strategy for executing the design, Drawings & documents generated will be for the purpose of construction with all details implemented from individual shop drawings and specifications, Parallel prefabrication is commenced, 3D modelling is developed, Cost is finalized through proper modelling, Specifications with proper descriptions provided, Proper and clear documents generated for the bidders and Information for procurement, schedule, layouts, commissioning and testing requirements, and contractual requirements finalized and documented.

Agency review is where agency / Third Party / End User review phase consists of: Electronic approvals, Document submission from contractors and approval and Detailed review by Third Parties and End user.

Buyout is occurring during this phase all balance contracts with vendors and subcontractors are executed to: Procurement of Long Lead Items, Bidding & Negotiations, Exact quantity bidding and ordering, Various competitive bidding strategies can be employed for bidding and Incentive or compensation for contractor and vendors involved in early design phase.

Construction occurs during construction Phase the following activities are performed: Less onsite engineering activities and change notes since all designs have been finalized early, Enhanced RFI process, Less submittals during construction, Consistent information ensures better understanding of design intent by all parties, More pre-Fabrication possible due to early detailed design, Less contingencies and surplus at site, Works better controlled, Warranty and operation details included in the model and Schedule monitored from the model which was more accurately estimated, Quality control, Owner directed change orders and periodic review of schedule and cost will remain unchanged compared to traditional model.

IPD provides positive value propositions for the three major stakeholder groups, owners have a better visibility of the project during early design phase which will allow them to align the project early with the business goals. Owner's expectations

are well documented and conveyed to the team thus enabling better cost control and schedule and quality implementation. Construction contractor inputs are implemented early in the projected thereby improving the quality and financial performance of the project. Better planning for construction activities since construction Contractor is involved from early design. Construction contractor has better understanding of the design and design related queries and issues are resolved early hence delays and cost over runs are controlled with better quality and HSE record. Designers where all the design decisions can be made early since the stakeholders will be available early during design. This will reduce rework and build more clarity in design. Improved project quality and financial performance due to early resolution of design issues before start of construction activities. The IPD process increases the level of effort during early design phases, resulting in reduced documentation time, and improved cost control and budget management, all of which increase the likelihood that project goals.

A Typical IPD Project Communication & Contract can be represented by the Figure below

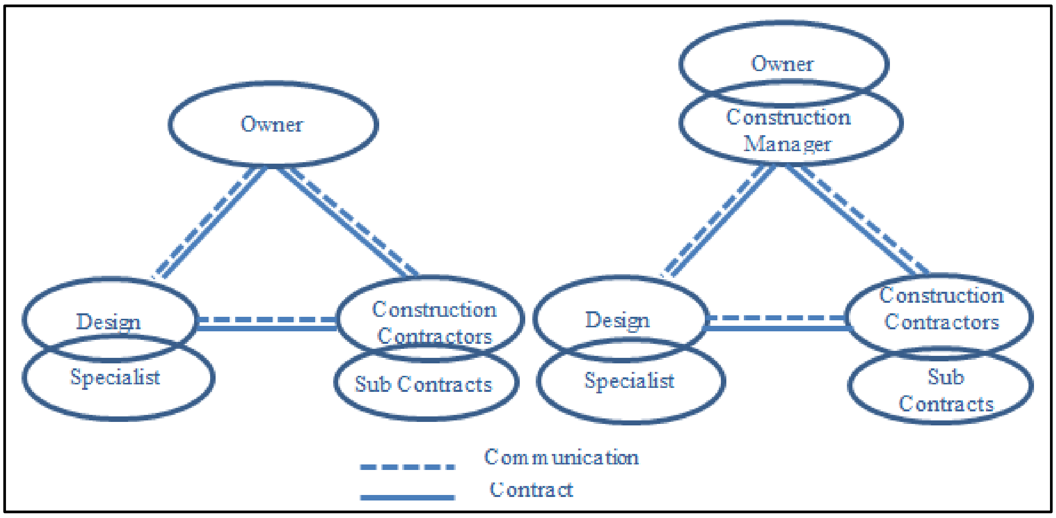


Figure (2.18) Integrated Project Delivery Communication and Contracts between Stakeholders
Source: (Adapted from American institute of Architects 1996)

2.11.2 IPD Role in Addressing Current Problems

IPD has been tried in some building Projects in the past with positive feedbacks from all stakeholders. Owners agreed that IPD model requires more active participation from owners but not additional resources as compared to traditional project delivery methods. The designers have pointed out that though IPD increases the design effort since it requires the Owner to have more information to enable more informed decisions early during design but IPD reduces the changes later during the project and also bidding and detailed design phases are compressed since majority of these work is done early. Construction contractor sees IPD approach as beneficial since it provides more transparency early during design which is more collaborative. Also having detailed design done with contribution from all stakeholders allows more accurate pricing for the project (AIA California Council, 2010).

In IPD Decisions are made collectively by all stakeholders which eliminates rework or redundant work (AIA California Council, 2010). A collaborative approach ensures the best skills are employed early in the project from all stakeholders thereby improving the efficiency of the whole development process. IPD allows early identification and resolution of design errors or conflicts since construction Contractors are involved in the early design phase. IPD also eliminates the number of communication channels thereby facilitates more streamlines flow of information between all stakeholders (AIA, 2007).

2.11.3 IPD Elements

IPD motivates collaboration throughout the design and construction process, tying stakeholder success to project success, and embodies the following contractual and behavioral principles.

Contractual Principles (AIA & AGC, 2011; AIA, 2007) are Key Participants Bound Together as Equals, Shared Financial Risk and Reward Based on Project Outcome, Liability Waivers between Key Participants, Fiscal Transparency between Key Participants, Early Involvement of Key Participants, Intensified Design, Jointly Developed Project Target Criteria and Collaborative Decision-Making.

Behavioral Principles (AIA & AGC, 2011; AIA, 2007) are: Mutual Respect and Trust, Willingness to Collaborate and Open Communication..

Catalysts for IPD (AIA & AGC, 2011; AIA, 2007) are: Multi-Party Agreement, Building Information Modeling, Lean Design and Construction and Co-location of Team.

Based on the basic principles of IPD Fig below shows the basic phases of the IPD and the stake holder involvement Vis-à-vis Traditional Contracts.

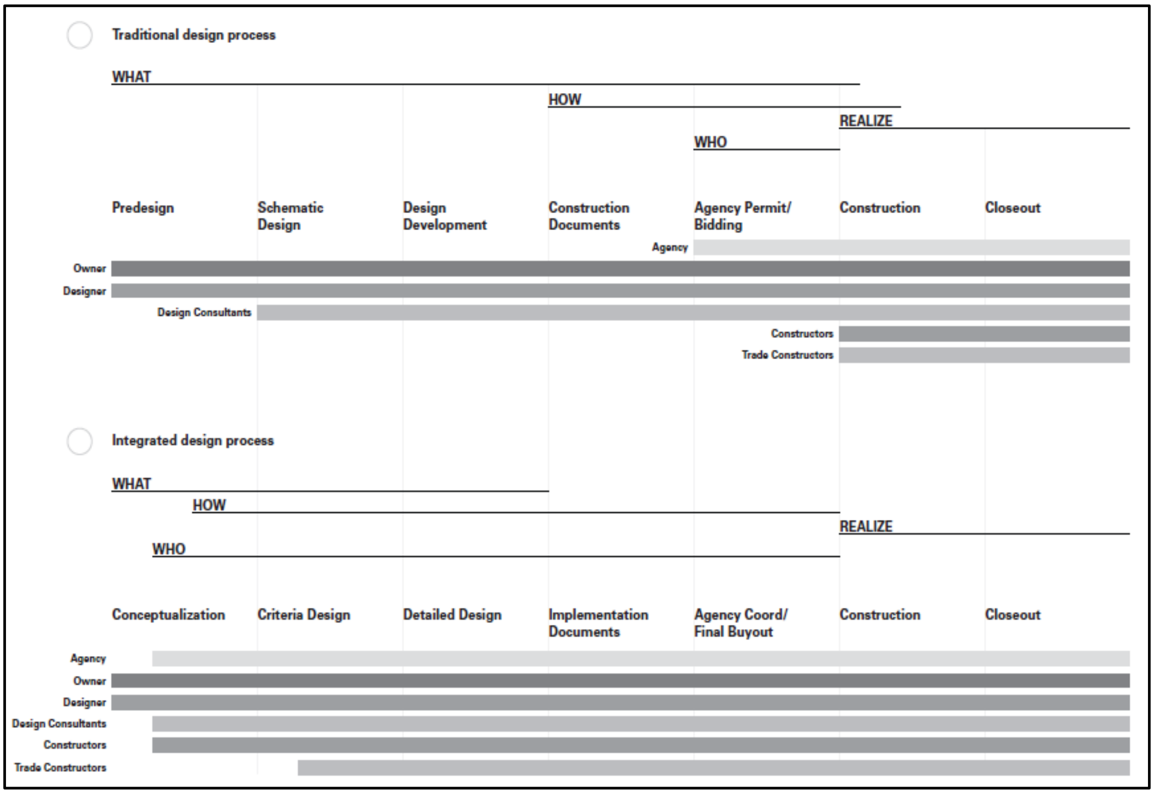


Figure (2.19) Integrated Project Delivery Vs Traditional Design process
Source: (Adapted from American institute of Architects 1996).

2.11.4 IPD Implementation in Construction

Choosing IPD as a delivery method for project needs careful considerations to several factors. IPD may not give the same kind of results to all scale and size of projects. IPD is envisaged to be extremely beneficial for large scale projects. Skills and capabilities of the team members is another critical success factor for IPD. Risk and reward sharing and implementing unbiased contractual conditions support the IPD project execution at several levels for achieving the desired benefits from the delivery method. The most commonly recommended principles of IPD for a successful project implementation are Target Cost Pricing, Co-location, Building Information Modelling (Development of integrated design information software), Lean training, use of cross functional groups and core groups, tracking accountability, implementation of lessons learned from past projects, decision documentation, value stream mapping and incentives liked to behavior and measurable outcome (KPMG, 2013). The IPD will have key integrations advantage over other mothods.

Sive, 2009, believes IPD encourages a more schedule and cost efficient execution and the risk of changes remains very low in the later stages of project. IPD encourages a team effort for success of the project and client satisfaction.

The key to implementation of IPD is in building a focus on specific measurable metrics for improvements desired in project performance. IPD implementation required education of all stakeholders on IPD principles and processes and demands sincere participation from all stakeholders and building trust between team members to openly share the information which will increase the overall value of the project (Sive, 2009). Ashcraft focuses on the behavioral aspects of the Owner such as Clarity of the goal, commitment to the process & willingness to support the cause, active involvement or engagement with the teams, collaborative leadership & creating integrity and trust. (Ashcraft, 2014). Roles and responsibilities must be clearly define in the IPD.

Ghassemi & Gerber, 2011 enlists the major barriers in implementing IPD and provides suggestions to overcome the same. Ghassemi considers Involvement of all team members and integrating the teams, IPD Training & Trust building can help overcome the Cultural barrier, a comprehensive Win-Win compensation structure & Cost and benefit sharing can help overcome Financial barriers and Insurance, Bonding can address legal barriers (Ghassemi & Gerber, 2011). The IPD could increase size of the stakeholder and increase their participation but requires clear roles for each of them.

2.11.5 Impact of Contracting Type on Project

The following table excerpted from Integrated Project Delivery: A Guide (AIA California Council, 2007) suggests some of the ways in which IPD differs from traditional project delivery:

Traditional Project Delivery		Integrated Project Delivery
Fragmented, assembled on "just-as-needed" or "minimum-necessary" basis, strongly hierarchical, controlled	**Teams**	An integrated team entity composed of key project stakeholders, assembled early in the process, open, collaborative
Linear, distinct, segregated; knowledge gathered "just-as-needed;" information hoarded; silos of knowledge and expertise	**Process**	Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect
Individually managed, transferred to the greatest extent possible	**Risk**	Collectively managed, appropriately shared
Individually pursued; minimum effort for maximum return; (usually) first-cost based	**Compensation / Reward**	Team success tied to project success; value-based
Paper-based, 2 dimensional; analog	**Communications / Technology**	Digitally based, virtual; Building Information Modeling (3, 4 and 5 dimensional)
Encourage unilateral effort; allocate and transfer risk; no sharing	**Agreements**	Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing

Table (2.2) Traditional vs integrated Project Delivery
Source: (Adapted from American institute of Architects 1996)

The table above excepted from Integrated Project Delivery: A Guide (AIA California Council, 2007) suggests some of the ways in which IPD differs from traditional project delivery. In comparing the Models, it is on the basis of Team, Process, Risk, Compensation, communication & agreements. The section below will compare Traditional delivery method (DBB) with Integrated Project Delivery (IPD).

Team is in a traditional model the stakeholders are different for different phases. The team players in each phase is shown in figure (2.13). Owner controls the design done by design consultant and then through bidding awards the construction contract to construction contractor. The designer and contractor/ sub-contractors have no communication. In IPD the design team builds the design with inputs from Construction contractor. The designer, construction contractor & sub-contractors and vendors jointly develop the project from design to handover (AIA, 2007). IPD can be delivered in various approaches and processes.

Process which again referring back to Figure (2.13), the traditional project delivery process is linear and all phases are phased one after the other. There is no overlap possible between design by consultant, bidding process for EPC award and Construction by contractor, sub-contractors and vendors. IPD encourages a very high degree of overlap between the project phases. The knowledge from contractors and vendors is embedded in the design by consultant and before the design is complete the construction contractor starts preparing his method statement and early works. Also during early design, the vendors are engaged and purchase orders are placed very early which fast-tracks the entire project considerably (AIA, 2007). Risk in Traditional project delivery the Design omission and design errors are owned by the owner who completely manages the design phase on his own. This design related risk remains with owner even after award of EPC since construction contractor builds the project as per the design documents provided by the Owner. Any impact on project schedule and cost due to design errors are impact for the owner. Similarly, any cost or schedule impact during construction is entirely a burden of the construction contractor. To mitigate that risk either the contractor cuts on the quality or adds a huge contingency to his cost (AIA, 2007). The IPD also has a liner steps and all stakeholders can participate in all the phases.

Compensation / Reward in Traditional Project delivery the reward or compensation for individual entities in the project is not aligned with the project outcome or objective. A design consultant gets his compensation on the man-hours expended during the design activity. No incentive is available for the designer for optimizing the design or adopting cost saving initiatives. Similarly, EPC contract is awarded on least cost basis which leaves the construction contractor with very less margin for profit. Implementing innovative construction techniques or cost savings during construction will not be for the benefit of the contractor, hence any cost saving initiative is met with resistance. Contractor is tempted to compromise on quality and increase his claims through change orders which are contradictory to the Owner's interest. In IPD the compensation or reward is linked with the performance of the project. If the project performance improves or if the total cost of execution or schedule is compressed, all stakeholders of the project gain from the initiative (AIA, 2007).

Communication / Technology is the communication between designer and construction contractor or vendor is not possible in a traditional approach. The construction contractor and vendors get design documents which restricts the contractor or vendor to build as per the designer with no knowledge sharing for better designs. In IPD all stakeholders develop a design with considerations to inputs and learnings from designer, construction contractor, owner, vendor, etc (AIA, 2007). The O&G project require management system to ensure smooth document records and handling have been achieved as minimum.

Agreements in Traditional Contracts are between two parties only and with risk transferred to one party through these agreements. In IPD the contracts are Multi-party contracts where the risk and rewards are equally shared between all parties. Multi-lateral IPD contracts encourages collaboration and joint initiative by all parties for project success (AIA, 2007). The current situation in the O&G could face problems for having more than one party responsible, however if there are clear contractual basis this type of agreements could be executed.

2.11.6 Advantages of Integrated Project Delivery

IPD encourages selection of design consultant, Construction Contractor and Sub-Contractors on the basis of their qualification. The Integrated approach makes the Delivery method highly efficient and enables crashing the schedule most effectively. Early involvement of all stakeholders like construction contractor, Sub-contractors and vendors enables a very thorough design with minimum rework. The risk is evenly shared with all stakeholders hence it's a complete team approach. All benefits or profits are evenly shared so the project is totally aligned with common project goals and objectives. (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf; CMAA, 2012; Kent & Bercerik-Gerber, 2010, p. 816). The IPD should support the O&G project competitive approach since it does not require single agreement.

A very accurate cost and schedule estimate with highly qualified team and early identification of risks and opportunities gives a very good visibility of the project and ensures completion of the project within schedule and budget estimates (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf).

Friedlander supports the claims of advantages of IPD for project delivery. He defines clearly the benefits to individual stakeholder and the project. In quality perspective IPD enables a direct contribution of Design Consultant and Contractor to the design phase of the project. With no Contractor in between to muffle the optimization and Value engineering efforts by the Design consultant the quality of design is noticeably better. The project preferences and objectives are visible to the team throughout the project development lifecycle as the same team continues from early design till construction and handover phase of the project. Since the Design consultant has access to the construction and pricing information during design phase the design is made cost effective. Procurement will be cost effective and more collaborative since IPD involves the Vendors during the design process. IPD has the flexibility to be implemented after the design phase (Friedlander C. Mark). The IPD method will play direct advantages since major stakeholder will participate in the design phase and this will improve the objective understanding and the uncertainty in the requirements.

Since the Construction contractor does not need to bid below achievable cost the claims and variation requests are minimum. Due to a good level of communication channels and collaboration between the design consultant and the construction contractor administration and co-ordination efforts from owner is minimum. With functional allocation of responsibilities and risk sharing less events of conflicts between teams. Benefit sharing model encourages all participants to work towards a common goal of optimum design, minimum construction cost and fast-tracked schedule for early and maximum profit realization for all stakeholders (Friedlander C. Mark). The IPD will improve the quality of cost estimate in the O&G projects since Contractors will have opportunity to clarify any requirements before costing.

For the design consultant it will be easier to give more accurate cost and schedule estimates and better quality documents with proper inputs from all stakeholders. Unrealistic or unnecessary design changes can be avoided and increased satisfaction amongst the team members can be achieved. Claims are almost non-existent since IPD works on a collaborative principle and not competitive (Duke et al., 2010; Friedlander C. Mark).

For the contractor early information on the design can provide good time for planning construction activities and find best methods to construct with least cost and maximum efficiency. Increased profits due to less rework and mismanagement or lack of information and work stopovers. Minimum contingencies need to be set for bidding errors or omissions (Friedlander C. Mark). The O&G project planning will be improved since all planning units of the stakeholders will have the opportunities to sit and discuss the schedule and deliverables risks.

Patrick Duke, Steve Higgs, McMahon R. William recommend IPD model for Project delivery for reasons such as equitable risk allocation, increased collaboration, Increased transparency, maximum returns on investment and increased trust between the stakeholders. The paper also states that with IPD the Owner, Design consultant and the contractor act as one entity. The owner can adopt the advantages of Design Build and CMAR models together by adopting IPD. IPD eliminates rework and redundant effort and hence reduces the project duration and cost (Duke et al., 2010). The IPD in the O&G will provide the execution contractor an early opportunity to identify his risks and how to mitigate them.

Amanda Fish quotes that even though the responsibilities of the IPD team members are well defined but if a team member needs to be changed over for reasons inevitable then since all team is equally involved in the project design and construction activity, the changeover process is smooth. (Fish, 2011). Information sharing between the team members is better as everyone shares a common objective and every information shared is contributing to the collective savings on the project and in return will benefit all the team players. Since planning activity can begin early, the construction mobilization and strategy can be built thoroughly during the entire design phase (Fish, 2010). The IPD could resolve the gap between the stakeholders and improve the changeover and handover between Design team and construction team.

2.11.7 Disadvantages of Integrated Project Delivery

IPD is relatively new delivery method with not many contractors, design consultants and vendors having thorough knowledge of the process. The forming and learning phase of the project is comparatively longer and the people to people communication and trust needs to be built very early to achieve the desired performance targets in the project (CMAA, 2012) Owners have to change their mindset from being drivers and decision makers and adopt a more collaborative approach for achieving project objectives, (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf). Multi-Party contracts are still evolving and to implement it and manage the same will be a cumbersome task (CMAA, 2012). (http://www.findorff.com/assets/pdf/DeliveryMethods.pdf).

Selection of the team is a difficult process because the owner has no way to gauge how the independent teams will perform as a single team for the project.

(CMAA, 2012; Fish, 2010) Cost estimation and control is a tedious process for this type of contract since all effort by teams will have to be measured objectively and benefits and compensations for the team has to be evenly defined in proportion to their contribution (CMAA, 2012; Fish, 2010). IPD has not been implemented widely so far hence the legal perspectives of IPD contracts is yet to be matured and ways to resolve disputes have to evolve (CMAA, 2012). Inexperience of team members on working with IPD can drift the project away from the objective and will not realize that the success of the project is in the best interest for all team members.

2.11.8 Difference between Alliancing and Integrated Project Delivery (IPD)

As Stated by Peter Raisbeck et. Al. The alliancing form of contracting differs from the integrated project Delivery form since Alliancing does not use Building Information Modelling (BIM) which is in contradiction to IPD where all teams use BIM. BIM is the fundamental platform which enables 3D modelling and data sharing between the team members (Raisbeck et. al, 2010).

2.12 Local Experience Literature

Contractors with the capability to execute design (FEED) have in the past designed and then participated in construction bidding. The strategy of contractor design followed by construct was stopped recently by some owners, because the contractor either withheld critical information in the design (FEED) so that it was not released to competitors or sometimes inflated the requirements in order to mislead competitors. Alternatively, a contractor executing the design could have more details that their competitors leading to the submission of a higher but more inclusive bid. This would lead to very competitive pricing from other bidders and eventually after the award of the EPC construction to another bidder, change orders or disputes for compensation would begin. This is why participation of a single contractor during the FEED design is discouraged by owners.

Major lessons learned workshop was conducted in 2013 in ADCO, UAE to identify the major causes behind delays of the last five Giga projects. Workshops included the majority of key stakeholders, including owners' project management teams (PMT), EPC contractors PMT, project management consultant teams and major vendor representatives. The main objective of the workshop was to allow the EPC contractors to express the factors caused by owners. There was a consensus from three of the contractors that a lack of information during FEED, over design and poor FEED design led to major uncertainties and high risk assumption. These collective factors were similar to the construction project factors; therefore, the workshop factors were added to construction project factors. It was discovered locally that many factors that related to construction projects also related to Oil & Gas, however not all factors were mentioned in the Oil & Gas discussion, therefore to enhance the list they were added.

Amongst the factors received from all the participants from Owner, Consultant, Contractor and sub-contractors it was highlighted that majority of the factors were carried forward from the design phase of the project. Several of these factors could have been resolved very early in the project such as conflicts in drawings and specifications, Design changes, disagreements or modifications in specifications, high performance or quality expectations, improper codes used for design, inaccurate material estimates or increase in quantities, lack of integration at early stage of planning or design, material changes in type or specification during construction, overdesign, poor qualification of consultant engineer’s staff, time extension, unrealistic client requirements and insufficient information. It was suggested by the participants that all the design and early planning and estimation related factors can be resolved early with proper inputs from Owner and having qualified engineers during design with design as well as construction related experience. Even though construction related experience was not a usual skill set amongst designers it can be substituted with additional stakeholders who can share their construction related experience with the design team early in the project. Conflicts or contract related issues sighted by the participants as the reasons for delay or cost overrun in the project, were attributed to unclear or errors in design during FEED, Changes in client requirement, improper bidding instruction, improper drafting of the contractual terms for EPC contract or contractor negligence or errors. All these reasons are again linked with the improper communication, coordination or documentation.

The other construction related factors were identified such as delay by construction contractor, such as delay in site preparation, delays in construction, changes in project or sub-contractor staff, improper construction milestone definition, inadequate progress review, which again points towards the insufficient or underqualified progress monitoring team and shortage of equipment. All the factors under construction contractor were considered to be resolvable if the Construction contractor is given sufficient time to study the project before estimating the cost and schedule for bidding for the project. Unrealistic schedules dictated by client is not challenged by contractor during bidding because of insufficient design information, ineffective communication, errors by contractor in estimation or insufficient time for bidding. Also improper planning by contractor and improper selection of sub-contractor for the EPC can be controlled by the contractor provided he clearly understands the design and client requirements and get sufficient time to do the pre-construction preparation work.

Delay factors from Lessons Learned workshop	
Conflicts during construction	Improper construction milestone definition
Conflicts of the Drawing and Specification	Improper technical study by the contractor during the bidding stage
Contract modifications	Inaccuracy of materials estimate
Contract negotiations	Inadequate progress review
Delay caused by contractor	Increase in Quantities
Delays in construction	Lack of integration of skills at early stage of planning & design
Delays in site preparation	Liquated Damage
Design Changes	Location
Disagreements or Modifications on specifications	Materials changes in types and specifications during construction
Excessive contracts and subcontracts	Overdesign
Failures	Poor qualification of consultant engineer's staff assigned to the project
Frequent change of project staff	Regulatory changes
Frequent change of sub-contractors because of their inefficient work	Shortage of equipment
High performance or quality expectations	Time extensions;
Improper Codes used for design	Unrealistic client initial requirement
	Waiting for information

Table (2.3) Delay factors were captured from local Lessons Learned workshop

2.13 Literature Review Summery

During the literature review, the researcher was focused to understand the current O&G projects practices and execution strategies. I was found that the sector has very wide range of processes and practices implemented and utilized. The Stage gate is one of the key processes utilized by the industry and it has resolved many issued related to the quality and deliver the projects systematically. Stage Gate process is providing the assurance to the owners to allow them to proceed with investments and move to the next phase. The Stage Gate disadvantage is yet does not bring the stakeholders early in the design phase to integrate and collaborate in order to improve the quality of deliverables. The gas still is exist and getting wider between stakeholder since the Stage gate require to pass the phase in order to engage the construction contractor and this keep the integration between stakeholder poo due to lake of integration.

The Literature has identified the factors behind poor performance and has recorded them very well. Factors were found repeated in majority of the gega size projects despite the projects are executed in difference countries. Literature also listed and ranked the factors and their value and impact on the projects. The researcher also tried to look for the factors behind poor performance in the general construction industry and factors were found repeated and they were ranked by some literatures.

The IPD was addressed in several literatures however, it was newly developed and there was more need to understand its contractual basis and requirements. More literatures are required with implementation lessons and improvements. IPD definition, advantages, disadvantages and guidelines are well recorded however implementation examples in the O&G sector not found.

Project execution strategies were found extensive and well explained in the literature. Examples also were presence in the literature. Design-Bid-Build, Design-Build and Construction manager at Risk, all were found well explained in the literature with advantages and disadvantages. Other approached such as alliances and partnering were found in the literature with examples. Local experiences were also found in the literature and recorded in conferences for O&G sector.

The researcher in the next chapter will understand the research methodology and the strategy to use in this research. The researcher will focus to opt for the best research strategy where the data collection will add value. Research will record, filter and group these factors in various methods to give them ranking and extract the factors, which are impacting the performance and frequently repeated. Grouping based on their category, such as design related factors, communication based factors, construction based factors, planning based factors and contract based factors will be provided. Also the researcher will group the factors to their phase of occurrence, i.e. were they happened during the design phase or bidding or construction phase.

Chapter 3. RESEARCH METHODOLOGY

3.1 Introduction

All research studies have three common things in general; one is philosophical assumptions behind the research, research strategy if it will be a quantitative, qualitative or mixed method strategy and finally is that which research methods are appropriate for the given study (Creswell, 2003). This section follows the same principles and explains the same approach.

Prior travelling further in this subject, it is necessary to define the term ‘Research’. The Advanced Learner’s Dictionary of Current English lays down the meaning of research as “a careful investigation or inquiry especially through search for new facts in any branch of knowledge.” (Hornby, A. S.et. al, 1975). The researcher believes in the underlying philosophical reason of research as rightly put by J. Francis Rummel as “an endeavour/attempt to discover, develop and verify knowledge (Rummel, Francis J. et.al, 1963). It is an intellectual process that has developed over hundreds of years ever changing in purpose and form and always researching to truth”. Another definition states that research is a systematic and careful inquiry or an examination to discover new information or relationships and to expand/verify existing knowledge for some particular reason(s) (Smith and Dainty, 1991).

The researcher will travel in this section in a systematic approach step by step from the Purpose of this Research, to Research Design, Research Philosophy, Philosophical Approach (Prospective) to explain the types, and then move to the Research Strategy, Research techniques for Literature Reviews to Data Collection Methods based on the researchers understanding, knowledge and approach deployed to achieve the stated aim and objectives of this study. The researcher also will address the basis and rationale behind the choice of the Research Philosophy, Philosophical Approach (Prospective), Research Strategy, Research techniques.

3.2 Research Structure

By having a comprehensive understanding of research types, research philosophies, research designs, research approaches, research strategies, data collection techniques, interviews designs and data analysis method. This research adopted an overall research structure, where exploratory research was the research type compared to other research types; descriptive, explanatory and predictive types since the poor performance causes will be looked at with O&G industry used practices and execution strategies, then will identify and analysis the major factors behind the poor. In addition, the early phases of this research focus on identifying and collecting the factors and problems behind the poor performance of the projects, which were executed in the past and their relation to the project execution strategy. As the exploratory method was considered to deepen the research on the problems, and questions were prepared to answer specific questions, the research moves towards its final stage.

The interpretivism was the research philosophy since the researcher believes that reality is indirectly constructed based on interviewees interpretation and is exploratory in nature. It is also believed that for the same project, different interviewees can have different perspectives hence the researcher attempts to interpret these views, in addition, the research requires the researcher to understand the current Oil & Gas execution strategies and current and then explore the poor performance factors, which have influenced the project delivery.

This research uses the deductive logic, since the research will collect the poor performance factors from various literatures and analysis them then validate them using case study. The case study interviewees will also investigate whether there are other major factors in the literature that have been missed and that have a major impact on project delivery.

The mixed method approach was the research approach applied in this research where both quantitative by the literature and qualitative by the interviewees from the case studies.

This research has adopted a case study strategy based on the level of investigations required to validate the factors behind the poor performance of the Oil & Gas industry along with the conceptual created framework in order to achieve the mentioned aim and objectives. This research follows the sequential design and mainly explanatory sequential design for the case study strategy. The researcher started by reading the available resources in the Oil & Gas projects practices and current execution strategies, then moved further in the literature to identify the factors behind the poor performance of this industry, then the literature expansion continued to cover the IPD principles and approach. All of this was under collection and analysis of quantitative data from the literature, which was followed by a subsequent collection and analysis of qualitative data by building the questions and conduct case study with the project expert stakeholders. Hence the qualitative results which were collected from the face to face interviews helped to explain the initial findings of the quantitative results.

The content analysis was adopted for the case study interviews, since the researcher intends to explore the key critical factors behind projects poor performance and how the IPD will facilitate the industry improvement, there is a need to derive understanding via concepts/themes that relate to the investigations from the views, attitudes and opinions of the interviewees and stakeholders.

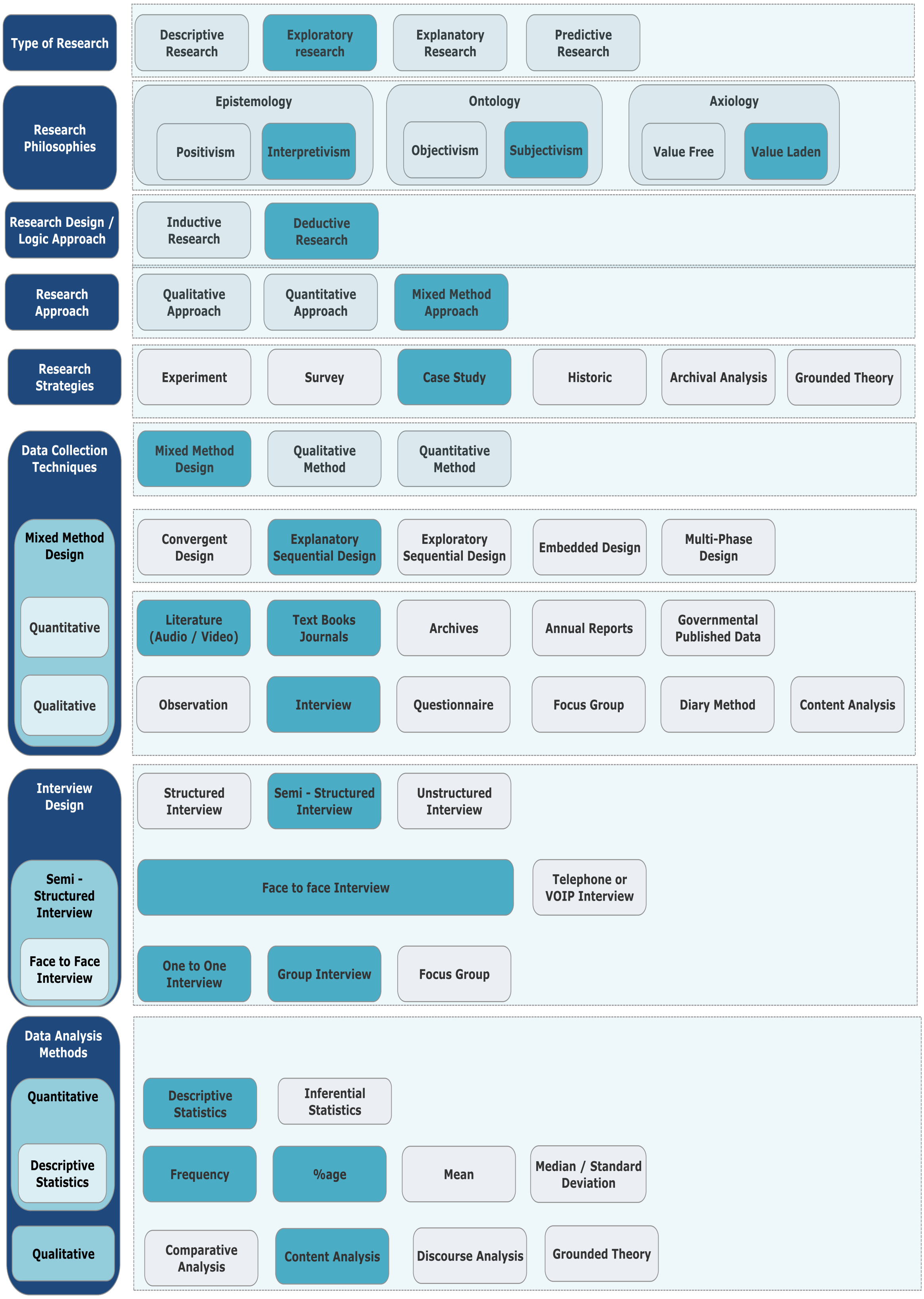
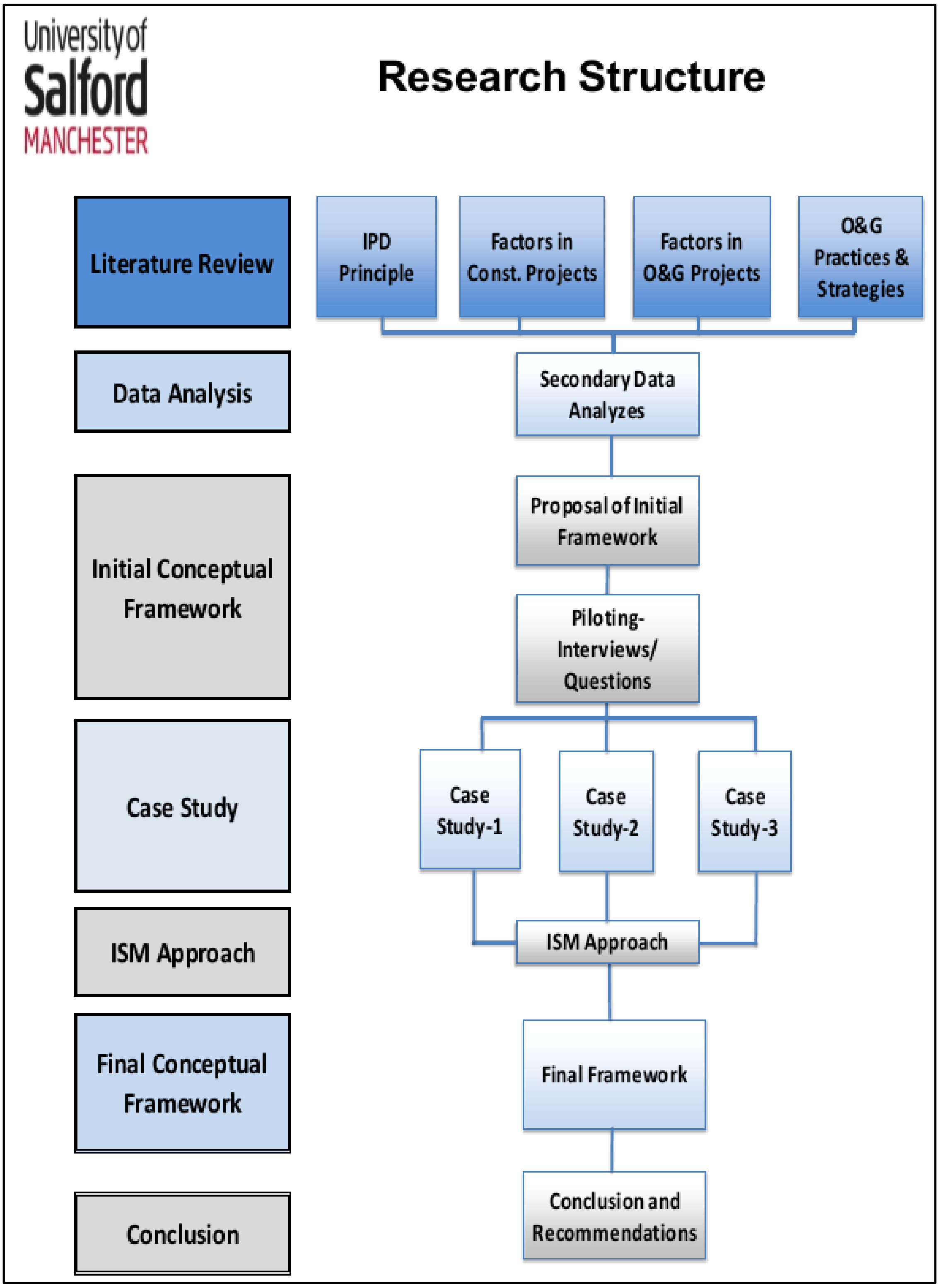


Figure (3.1) Research Structure (Methodological) Matrix



Figure(3.2) Research Structure (Methodology) Milestones

This research is divided in to seven main stages with further sub stages.

Stage (1): Literature Review: The researcher carried out an extensive literature review of the main topics below:

1. A literature review to understand the IPD approach, where it is implemented and what the current problems with IPD implementations are.
2. A literature review to understand the factors behind poor performance in the Oil & Gas industry and identify and quantify the size of these factors in this industry.
3. The literature review was extended to cover the construction industry as it was noticed that there is limited literature addressing the Oil & Gas projects.
4. The literature review considers the current Oil & Gas project execution strategies in order to understand any factors of current projects and sequence of stages and phases.
5. Understanding the execution strategy will assist in putting the factors into categories and understanding IPD implementation in the Oil & Gas industry.

Stage (2): Data Collection and Analysis: All of the factors will be consolidated and categorized to present a list of Oil & Gas factors and construction factors. This will assist in understanding the size of the factors and categorize, source and time of occurrence for each factor.

Stage (3): Initial Conceptual Framework: In order to implement the IPD approach, an initial framework and model will be developed. Since any Oil & Gas project implementation strategy has sequential stages and milestones, the sequence of these stages impose a specific time for each stakeholder's involvement and contribution, so the IPD should overcome this sequential stage strategy and should include the stakeholders during design to resolve the respective factors.

Stage (4): Piloting and Selection of Case Studies: The researcher will select three case studies to validate the framework, the selection criteria is based on the Oil & Gas industry. In order to have high quality questions and to improve the interviews, the researcher will perform the piloting with two to three expert in order to obtain their feedbacks and make any necessarily changes to improve the interviews times and outcomes.

Stage (5): ISM Approach: Interpretive Structure Modeling approach was implemented to identify the relationship between the poor performance factors and their influence on each other.

Stage (6): Final Framework: Based on the case study results and discussion with project related stakeholders, the initial framework will be adjusted (fine-tuned) to reflect the real requirement and case study outcomes.

Stage (7): Research Recommendation: Upon completion the final framework and feedback from all the related stakeholders, conclusion, recommendations, implementation guidelines, research limitation, future areas output will be produced to assist new Oil & Gas projects to utilise an IDP approach and to assist future research and analysis.

3.3 Purpose of Research

This research is designed and developed to focus on the project poor performance of Oil & Gas projects, which leads to schedule delays, cost overruns, poor quality, claims and problems during the operation which eventually, resulting in production losses for clients. Poor performance has stimulated the Oil & Gas industry to search and look for better practices, execution strategies and methods in order to improve the project performance by minimizing the cost overrun, and meet project recovery and production schedule. That has eventually brought the researcher to focus to develop a better project delivery practice and method, which should contribute to project practices and lead to better performance. Subsequently the researcher emphasises on the philosophical views, strategies of enquiry this research is based upon and research methods followed. The aim of this study is to create a conceptual framework to effectively implement an IPD approach in Oil & Gas projects. It is expected that IPD will help in improving the project performances and practices by touching the main factors behind the poor result; such as design factors, communication, planning, procurement and resources; this should contribute to improve project practices, schedules and control cost overruns.

3.4 Research Design

The Sage Encyclopedia of Qualitative research methods defines Research Design as “The way in which a research idea is transformed into a research project or plan that can then be carried out in practice by a Researcher or Research team” (L. M. (Ed), 2008). The researcher understands that Research Design bears more depth than the methods, which are employed to collect data for the study. Research Design represents the decisions on how the research is conceptualized, the conduct of research and the type of contribution the research is expected to make towards development of new knowledge in the field of research (Yin, 1989). As Yin rightly puts it, “Research Design 'deals with a logical problem and not a logistical problem'” (Yin R. K., 1989). In other words, “The Research Design articulates what data is required, what methods are going to be used to collect and analyse this data, and how all of this is going to answer your research question” (Van Wyk, B., 2012).

Creswell has described the Research Designs in other way as “plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis” (Creswell, 2009). Creswell also associates the selection of appropriate Research Design is based on the nature of research problem or issue in focus, personal experience of researcher and the audience of study (Creswell, 2009). This description has been stressed further by Saunders et al., by stating “Research Design is a framework for the collection and analyses of data to answer the research question and meet research objectives providing reasoned justification for choice of data source, collection methods and analysis techniques” (Saunders et al., 2012).

According to Saunders, Lewis, and Thornhill (2012), Collis and Hussey (2009). There are various types of research as shown below, undertaken for informative, investigative, clarification of forecast purposes though, there could be possible reasons for a combination of the types in a single research.

S.No	Type of Research	Reasons
1	Descriptive	To inform about the status of an occurrence,
2	Exploratory	To gain insight into a problem where there are limited earlier investigations,
3	Explanatory	To clarifies how and why an occurrence exists in order to proffer solutions
4	Predictive	To forecast the tendency for a similar situation in a particular context to occur elsewhere.

Table (3.1) Research Types
Source: Compiled from studies by Saunders et al. (2012) and Collis and Hussey (2009),

This research is exploratory in nature. Where Oil & Gas project poor performance will be looked at along with the current used practices and execution strategies, then also the research will identify the major factors behind the poor performance of Oil & Gas projects which lead to cost overruns, schedule delays and poor product quality. In addition,, the early phases of the research focus on identifying and collecting the factors and problems behind the poor performance of the projects, which were executed in the past and their relation to the project execution strategy. However, as the exploratory case study method was considered to deepen the research on the problems, and questions were prepared to answer specific questions, the research moves towards its final stage.

3.5 Research Philosophy

Wilfred Carr (1997) has addressed the historical meaning of philosophy by citing Aristotle's views about practical philosophy as "science which yielded practical knowledge to promote the good life and the good society through morally right actions" (Carr, 1997). Wilfred also explained the Plato's views that "any educational inquiry always entails some philosophical understanding of the nature of 'the good society' and of the kind of cultural, political and economic roles that individuals must be educated to perform if such a society is to be created and sustained" (Carr, 1997). Research philosophy is a term involving the development and nature of knowledge, embracing assumptions of how the world is viewed from different standpoints (Saunders et al., 2009). Holden and Lynch (2004) lectured that research philosophy importantly informs the predetermined assumptions concerning inter-related concepts. Therefore, an understanding of research philosophy and the adoption of a philosophical stance is seen as the first step towards appropriate choices and decisions of subsequent choices along the research methodological path (Kagioglou et al., 1998). Easterby-Smith, Thorpe, and Jackson (2008) mentioned three main reasons behind understanding the research philosophy; firstly, the clarity it provides in the research design; secondly, it helps the researcher to identify which design will work and which will not; and lastly, it helps the researcher to identify and even create designs that may be outside the researcher's past experience. Drawing from the aforementioned reasons, it is important in order to address different issues in this research.

There are three major ways of thinking viewpoints regarding research philosophy established by philosophers: epistemology, ontology and axiology. Failure to think through philosophical issues, while not necessarily fatal, can seriously affect the quality of research, which is central to the notion of research design (Easterby-Smith et al, 2003). Saunders, Lewis & Thornhill (2009) concluded that the research philosophy represents the way in which a researcher views the world. This philosophy will support the selection of research strategies and methods to meet the research objectives. There are two commonly and widely identified philosophy branches, namely epistemology and ontology (Fellows & Liu, 2008).

Research Onion Research Nested Model: The epistemological and ontological philosophy divisions can lead to a different methodology to be tackled for the research (Monty, 2011). Epistemology and ontology are within the foundational structure of philosophy and mutually support each another (Lombardo, 1987; Reber, 1995). This explains that the nature, origin, and scope of knowledge that the researcher is going to generate and deal with all are related to the philosophies which will be applied and considered during the research period. On the other hand, the nature and concept of reality and existence of the research, will decide and determine the method and the process which the researcher should select and which methodical approach that the researcher should follow and adhere to answer the research questions.

The philosophies have been studied carefully to assist with the identification of the optimum approach to develop this research structure and research methods. All of these steps which include reading and understanding various research structures, processes and procedures have guided and assisted in providing a good picture of the way how this research should be designed to reach the research aims and objectives target (Saunders et al., 2012). All of the above milestones, steps and procedures for the research design have been explained by the research onion diagram, as illustrated below, which shows how the researcher is travelling from the wide bandwidth to a narrower bandwidth; i.e. from wide research philosophy to detailed and narrow techniques of data collection and analysis.

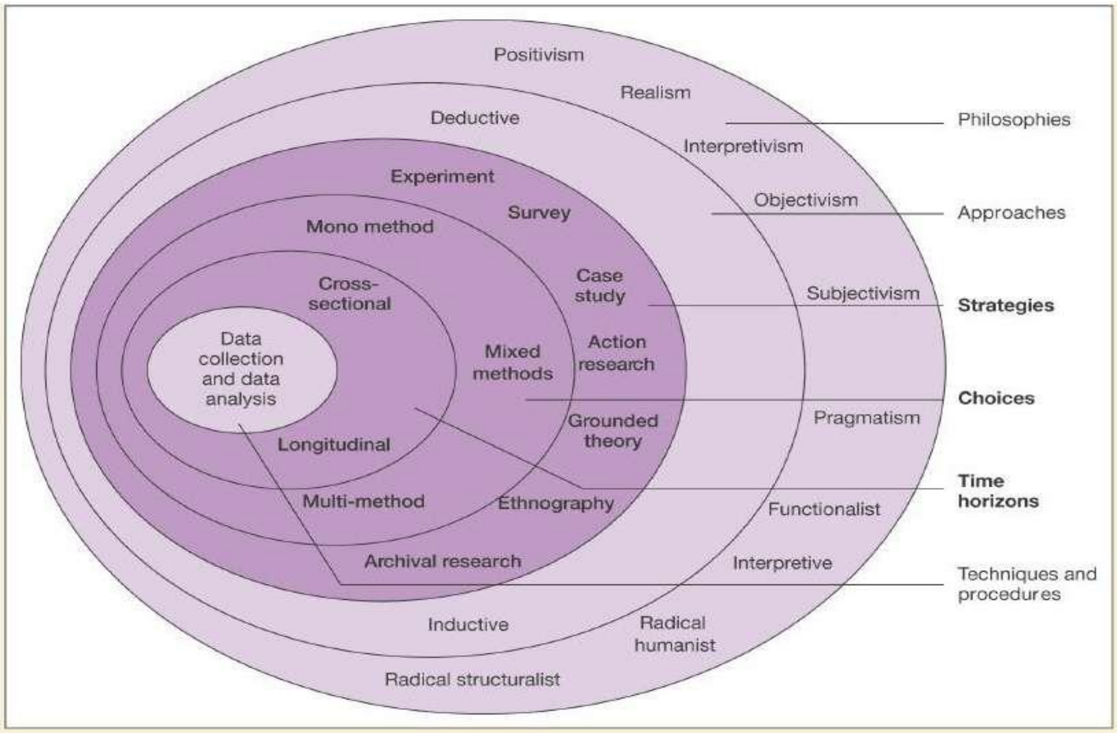
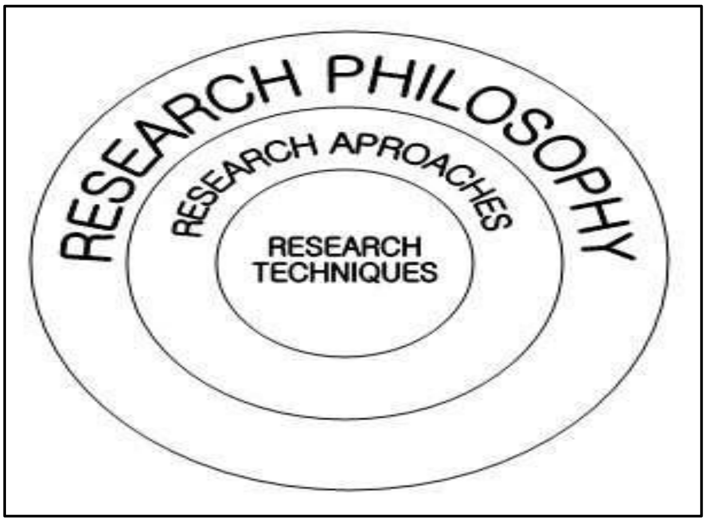


Figure (3.3) Research Onion
Source: (Saunders et al., 2012)

The onion diagram could be the most illustrative diagram to explain the research approach. The first two outer (wider) films address research philosophies and approaches, where the next three (films) layers are focusing on research processes (Saunders et al., 2012). He explained the researcher's journey through the research onion layers by stating, "the way you choose to answer your research question will be influenced by your research philosophy and approach. Your research questions will subsequently inform your choice of research strategy, your choice of data collection techniques and analysis procedures, and the time horizon over which you undertake your research project" (Saunders et al., 2012).

Nested Model: Although the research onion methodology summarizes almost all aspects of research methodology and provides a very logical sequence for performing research, the Nested Model described below was generated by Keraminiyage (2013) as a more flexible model. It provides the researcher with a good number of options to choose between approaches and provides great flexibility in planning the research. For example, one can define the time horizons before the research choices as they are not really dependent Keraminiyage (2013). The Nested Model is another simplified methodological model considered as methodology framework research; as shown in Figure 4.2, "The outer ring represents the unifying research philosophy, which guides and energizes the inner



research approaches and research techniques" (Kagioglou et al., 2000).

Figure (3.4) Research Nested Model

Source: (Kagioglou et al., 2000)

The figure shows how research onion methodology and the Nested model both deal with the research methodology and follow the same major sequence.

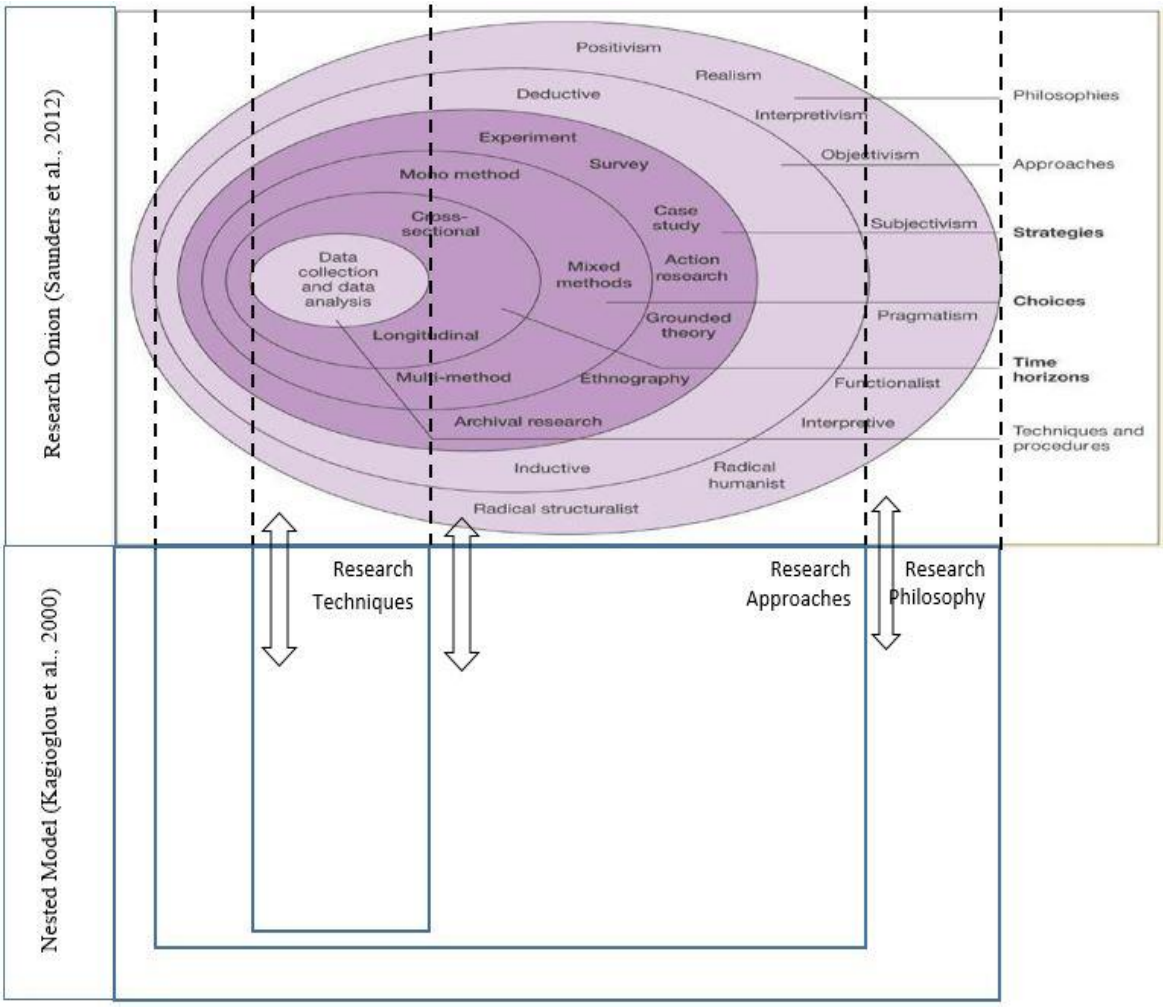


Figure (3.5) Comparison between the Research Onion and Nested Model
Source: (Keraminiyage, 2013).

By considering the above views of philosophy and the available research knowledge (epistemology) and the existence of social reality (ontology).

There are two divisions (epistemology) and the existence of social reality (ontology); positivist and interpretivists researchers. As Carson described, positivist researchers remain detached from research participants by creating a distance, which is important in remaining emotionally neutral to make clear distinctions between reason and feeling (Carson et al., 2001). Interpretivists favour qualitative data – they try to analyse behaviour in depth and from the point of view of the individual (Carson et al., 2001). That explains why the majority of researchers prefer unstructured interviews, where the researcher can ask more about the questions in depth and they can expand the discussion and participant observation; this always helps the researcher to understand the behaviour of the studied group by doing the same things and being in their atmosphere all the time.

3.5.1 Ontology

Crotty (1998) defined ontology as the study and science of being, concerned with what forms reality. This philosophical assumption is concerned with the concept of nature and reality, which exists dependent or independent of the social actors (Saunders et al., 2012). There are two main continuums of ontology objectivism and subjectivism (Saunders et al., 2012; Holden & Lynch, 2004; Crotty 1998). Ontology is a division and another leg of philosophy (within metaphysics) that addresses the nature of being and reality (Lombardo, 1987; Reber, 1995); in other words, ontology defines what is real in the world, whether physical or abstract structures. Those interested in learning and instruction can indicate their ontological preference by specifying what are considered truths about knowledge, information, and the world. To be redundant, yet succinct, ontology refers to "what exists" while epistemology is concerned with "how we come to know about" what exists (Barab et al., 1999; Jonassen, 1991). Ontology was expressed as the study of the nature of reality or existence and its logically coming before the epistemology (Lawson, 2004). Sexton has described the research in his standpoint as "the three axes of research philosophy, namely epistemology, ontology and axiology" (Sexton, 2004).

The study area is mostly characterized by the poor performance of the Oil & Gas projects and the factors and practices behind this poor performance, which eventually lead to poor project delivery and high cost overruns, which have encouraged this research. Thus the realities of such causes in relation to current poor project performance lie within the experience, techniques and managerial actions of the project team involved. Therefore, reality is created from interpretations based on the perception and consequent actions of the social performers. Reality is somehow confined to the mind based on ideas and is "socially constructive" (Saunders et al., 2012; Creswell, 1994 cited in Collis and Hussey, 2003). Therefore, reality is created based on perceptions of these projects which lies with the ontological philosophical assumption of subjectivism and not external and independent of the social actors as in the case of objectivism (Saunders et al., 2012). Therefore, this research leans towards the ontological philosophical assumption of subjectivism. Also the subjective approach was important in order to explore many aspects associated with poor performance factors in various projects related to Oil and Gas.

3.5.2 Epistemology

An epistemology is a philosophical belief system about who can be a knower (Guba & Lincoln, 1998; Harding, 1987; Hesse-Biber & Leavy, 2004). Epistemology, according to the Oxford English Dictionary, is the theory or science of the method and ground of knowledge. Epistemology addresses the "origins, nature, methods, and limits of human knowledge" (Reber, 1995), focusing on questions about knowledge and the nature of knowledge (Everitt and Fisher, 1995). Creswell stated that epistemology is the technical term for the theory of knowledge. It explains "how a researcher knows about the reality and what knowledge should be acquired and accepted" (Creswell, 2003). This philosophical assumption according to Crotty (1998) "is a way of understanding and explaining how we know what we know". Epistemology is concerned with providing a philosophical context to decide what type of knowledge is possible and how to ensure that it is both adequate and legitimate (Maynard, 1994). It is concerned with the study of knowledge, based on what is expected to be valid and acceptable knowledge in a field of study and involves the examination of what is being research in relation to the researcher (Saunders et al. 2012; Collis and Hussey, 2009). In brief, epistemology defines: What is knowledge? How is knowledge acquired? And How can knowledge be justified or reasonable?

There are two epistemological philosophies, namely positivist and interpretivist. 'Positivism' characterizes that there are observable facts which can be observed and measured by an observer (Fellows and Liu, 2008). The term positivism was first introduced by Auguste Comte, the French philosopher who believed that reality can be observed. Cohen, Manion, and Morrison (2007) claim that “Comte’s position was to lead to a general doctrine of positivism which held that all genuine knowledge is based on sense experience and can be advanced only by means of observation and experiment”. Aristotle, Descartes, Galileo, Auguste Comte, Vienna Circle, Francis Bacon & Karl Popper were few of the renowned thinkers who were associated with Positivist philosophy (Mack, 2010).

According to Creswell, the objective of ‘interpretivism’ is to enhance the overall understanding of the specific subject of research (Creswell, 2003). Also, it allows the researcher to acquire a richer and more thorough understanding of their subject. The interpretivist paradigm can be also called the “anti-positivist” paradigm because it was developed as a reaction to positivism. It is also sometimes referred to as constructivism because it emphasises the ability of the individual to construct meaning. (Mack, L., 2010). Interpretivism (Saunders et al., 2012; Collis and Hussey, 2009) although realism and pragmatism have been additional identified (Saunders et al., 2012). Interpretivism’s main principle is that research can never be objectively noticed and observed from the external, rather it must be observed internally throughout a direct experience of people/subjects. Furthermore, uniform causal links that can be established in the study of natural science cannot be made in the world of the classroom where teachers and learners construct meaning. Therefore, the role of the scientist in the interpretivist paradigm is to, “understand, explain, and demystify social reality through the eyes of different participants” (Cohen et al., 2007). Researchers in this paradigm seek to understand rather than explain (Mack, 2010).

For this research, the underlying philosophical approach assumed is that of the interpretivist, since the researcher believes that reality is indirectly constructed based on individual interpretation. This research is also mainly exploratory in nature. It is also believed that for the same event, different people can have different perspectives hence through this research the researcher attempts to interpret these views of the subject matter experts and participants. However, this study focuses on positivism and interpretivism as the two main continuums as the views of realism and pragmatism draw concepts from these stances. This research falls under epistemology; it includes both epistemology philosophies (positivist and interpretivist) but uses mainly interpretivism in its approach, as the research requires the researcher to understand the current Oil & Gas execution strategies and current industry practices. The researcher will also explore the Oil & Gas factors behind the poor performance, which have influenced the project delivery and caused time and cost impacts. The same was explored in the infrastructure industry and general construction industry and the similarity was verified. When the understanding and the explanations have been made, the researcher will have produced opinions and views from different project stakeholders, where interviews will be established with key participants then collect their feedback and experiences and then verify the secondary factors collected by the literature.

3.5.3 Axiology

Value theory is dealt with in economics, in ethics, and in various other disciplines. In philosophy, axiology refers to the philosophy of value. As quoted by Douglas G. Block, "axiology" is widely described as the study of value. This definition should be expanded to include "value." (Douglas G.B, 1973). A classic definition of "value" is contained in the observation by Brightman and Beck: "It is common practice to use the word value to designate the realm of what is esteemed to be intrinsically worthy as an end of human action or enjoyment." (Brightman & Beck, 1963). Hence, it may be fairly concluded that the "standards" referred to by Thonssen, Baird, and Braden contain values as one of their constituents (Thonssen, Baird, and Braden, 1970).

Research is not ‘neutral’, but rather reflects a range of the researcher’s personal interests, values, capabilities, assumptions, purpose and ambitions. Axiology is the aspect of research philosophy that deals with the judgments of value and its importance to the credibility of the research results (Saunders et al., 2009). Value plays an important role in interpreting results. It relates to the own values of the researcher in the various stages of the research process. Heron and Reason (1997) argue that values are the guiding reason of all human action, and the axiological skill to articulate values as a basis for making judgments is essential in every research. Values could be laden and biased or free. Given that the researcher has wide experience in Oil & Gas projects and knowledge will be needed to construct views and experiences of participants and case studies, value input into the investigation becomes a part and parcel to understand what is being studied. From an axiology point of view, the research can lean towards a value bias (value-laden); however, every effort has been made to minimize such bias by adopting multiple research techniques to triangulate the findings.

3.6 Philosophical Perspectives

Philosophical perspectives reflect certain assumptions with respect to the nature of the world and how we come to know about it; however, these are sets of beliefs and are not open to proof in the positivist sense of the word: “There is no way to elevate one over another on the basis of ultimate, foundational criteria” (Guba and Lincoln, 1994).

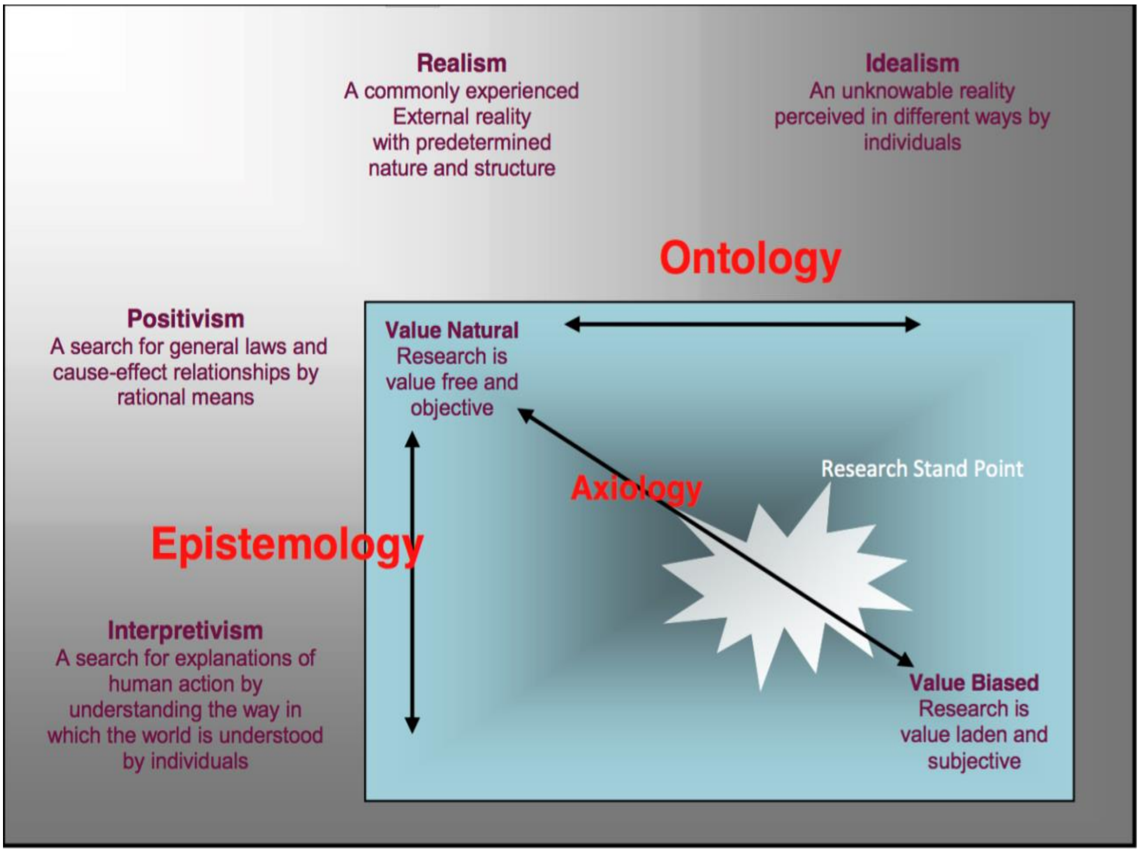


Figure (3.6) Dimensions of research philosophy

Source: (Sexton, 2002)

3.6.1 Research Approach

John W. Creswell was one of the first to discuss various research methods that have evolved over a period of about two decades. Creswell focused on three main types of the research: qualitative, quantitative and mixed method approaches. This approach adopts the use of measurements and tests and collects data on predetermined instruments that yield statistical data. Thus knowledge claims based on positivist grounds and deductive logic (Saunders et al., 2012; Collis and Hussey, 2003; Creswell 2003). There are two methods of reasoning have a very different "feel" to them when researcher conducts research. Inductive reasoning, by its very nature, is more open-ended and exploratory, especially at the beginning (Guba and Lincoln, 1994). Deductive reasoning is narrower in nature and is concerned with testing or confirming hypotheses. Even though a particular study may look like it is purely deductive, most social research involves both inductive and deductive reasoning processes at some time in the project.

This research uses the deductive method, since the research will collect the delay factors from various literatures and projects will then use a case study with questions to validate and seek the interviewees' opinions on the delay factors which have been collected from the literatures. They will also investigate whether there are other major factors in the literature that have been missed and that have a major impact on project delivery.

3.6.2 Mixed Method Approach

Mixed methods, in which quantitative and qualitative methods are combined, are increasingly recognized as valuable, because they can capitalize on the respective strengths of each approach.

The mixed method has apparently evolved from the constraints of the lack of a best suitable single approach to examine, explore or explain relationships among variables in a particular situation. It involves the combination of deductive and inductive logic process of moving from theory to data (deductive) and data to theory (inductive) or vice versa (Saunders et al., 2012). According to Creswell

(2014), the mixed method approach adopts a knowledge claim based on pragmatic grounds. One of the advantages of this approach is its ability to mix worldviews, numeric and non-numeric data at the collection and analysis stages all within a single study. It further allows expansion and triangulation, which can overcome the potential criticism of a single method strategy (Denzin, 1970 in Collis and Hussey 2003).

This research uses the mixed approached, combining quantitative and qualitative material to achieve various aims. The qualitative and quantitative components will be performed concurrently and sequentially at times. It depends on the nature of the research steps and techniques, including verifying findings from Oil & Gas literature on the factors behind poor performance and existing practices. It also looks at the literature on Oil & Gas delay factors and which factors are frequently repeated in the industry, as well as verifying the similarity between the Oil & Gas industry and the infrastructure and general construction industry as if the factors are repeated in both industries. The literature reviews are expanded to cover the IPD definition and principles, by the literature the researcher has gathered more complete data. The researcher will use the collected quantitative data to create a conceptual framework to implement the IPD principle in the Oil & Gas industry, then validate the collected factors with key project stakeholders. The framework will then be validated with them using a case study and questions. The researcher defines the methods implemented to collect data relevant to the research objective and the research methodology to progress step by step in the effort to identify the Oil & Gas industry specific factors behind the poor performance and to conceptualize a framework to improve the projects performance.

Creswell (2005) highlights the basic considerations for determining the method of research. These are: “Match the approach to the research problem”: Qualitative methods are employed in research where explorations need to be made whereas quantitative methods are employed in research were trends or explanations have to be made (Soiferman, 2010). “Fit the approach to the audience” and “Relate the approach to the researcher’s experiences”: Research using either qualitative and quantitative needs skills in conceptualizing research, conducting study and presenting the study. However, employing quantitative methods requires the researcher to have a certain degree of knowledge of statistics, data collection approaches and measurement, whereas qualitative research is mainly based on data gathering skills, data observation and interviewing (Creswell, 2005, p. 54). In order to address the limitations of qualitative and quantitative data collection methods, the researcher adopted a midway by using multiple methods and validating the historical data available from various sources such as research papers, literature and online resources with personal interviews and focus groups (Green, G., Kennedy, P., and McGown, A, 2002.). The collected data was then validated by project stakeholders in the case study questions (qualitative).

Catherine Marshall & Gretchen B. Rossman (2006) speak of the major advantages and disadvantages for each of the data collection methods. The same has been studied by the researcher to arrive at specific data collection method for this research.

Table 4.1 Strengths of Data Collection Methods

	PO	*O*	*I*	*FG*	*DR*	*N*	*HA*	*F*	*IA*	*UM*	*Q*	*PT*	*DA*	*C*
Fosters face-to-face interactions with participants	x		x	x		x						D		
Useful for uncovering participants' perspectives	x		x			x						D	D	
Data collected in natural setting	x	x	x	x	D	x		x	x	x				
Facilitates immediate follow-up for clarification	x		x	x		x			D					x
Good for documenting major events, crises, conflicts	x	x		x	x	x	x	x					x	
Collects data on unconscious thoughts and actions	x				D	D		x	x	x		x		
Useful for describing complex interactions	x	x	x	x		x	x	x	x			D		
Good for obtaining data on nonverbal behavior and communication	x	x	D	D		D		x	x	x		D		
Facilitates discovery of nuances in culture	x	x	x	x	D	x	x	x	x	x				
Provides for flexibility in formulating hypotheses	x	x	x	x	D	x	x	x	x	x				
Provides context information	x	x	x	x	x		x	x					D	
Facilitates analysis, validity checks, and triangulation	x	x	x	x	x			x	x	x	x	x	x	
Facilitates cooperation	x	D	D	x		x						x		x
Data easy to manipulate and categorize for analysis					x				x	D	x			
Obtains large amounts of data quickly		x		x			x	x				x		
Allows wide range of types of data and participants	x			D	D				D	x				
Easy and efficient to administer and manage					x		x		x	x	x			x
Easily quantifiable and amenable to statistical analysis					x				x	x	x	x		
Easy to establish generalizability					D		D		x		x	x		
May draw on established instruments					x				x	x	x	x	x	x
Expands access to distant participants					x						x			x

NOTE: x = strength exists; D = depends on use; PO = participant observation; O = observation; I = interview; FG = focus-group interviewing; DR = document review; N = narratives and life histories; HA = historical analysis; F = film; IA = interaction analysis; UM = unobtrusive measures; Q = questionnaires and surveys; PT = psychological techniques; DA = dilemma analysis; C = internet.

Figure (3.7) Strengths of Data Collection Methods
Source: Catherine Marshall & Gretchen B. Rossman (2006)

Table 4.2 Weaknesses of Data Collection Methods

	PO	*O*	*I*	*FG*	*DR*	*N*	*HA*	*F*	*IA*	*UM*	*Q*	*PT*	*DA*	*C*
Leads researcher to fixate on details	x	x		D	x	x		x	x	x	x	x		x
Possible misinterpretations due to cultural differences	x	x	x	x	x	x	x	x	x	x	x	x	x	
Requires technical training								x	x		x	x		
Dependent on cooperation of key individuals	x		x			x						x		
Readily open to ethical dilemmas	x	x	x			x		x		D		x	x	x
Difficult to replicate	x	x	x	x		x	D	x				x		
Data more affected by research presence	x	x	X	x		D		D	D			D	x	
Expensive materials and equipment								x		x				
Can cause discomfort or even danger to researcher	x											x		
Too dependent on participant openness/honesty	x		x			x							x	x
Too artistic an interpretation undermines research	x	x	x	x		x	x	x				x		
Dependent on "goodness" of initial research question		x		x	D		x	x	x	x	x		x	x
Dependent on the researcher's interpersonal skills	x	x	x	x	x	x	x					x		

NOTE: x = weakness exists; D = depends on use; PO = participant observation; O = observation; I = interview; FG = focus-group interviewing; DR = document review; N = narratives and life histories; HA = historical analysis; F = film; IA = interaction analysis; UM = unobtrusive measures; Q = questionnaires and surveys; PT = psychological techniques; DA = dilemma analysis; C = internet.

Figure (3.8) Weaknesses of Data Collection Methods
Source: Catherine Marshall & Gretchen B. Rossman (2006)

The context of this research encourages various data collection sources; however, the main three data collection channels which were implemented based on the research objective (Hox & Boeije, 2005; Meurer, et. Al. 2007; Sandelowski, 2000; Morse, 2003) are: Data collected from the currently published literatures (documentary data), Data collected from local experiences projects and Data collected from Oil & Gas experts in the piloting of the questions, the survey and the focus group workshop.

It is essential to identify the steps which were taken to arrive at this point of the research. The researcher has crossed various mandatory progress milestones in order to reach the research design level. The research questions, research outputs, aim and objectives have been defined along with key Oil and Gas delay factors and Oil & Gas current execution strategies also were identified, and the literature reviews were conducted to quantify the various delay factors and identify the frequency of each factor, along with the IPD practices and definitions.

The documentary data analysis helped to identify the current oil and gas execution strategies and quantify the delay factors occurred in various projects, frequency of the delay factors in various project with projects' location and sizes and other problems related to the impact on Oil & Gas costs and scheduling. The documentary data also assisted in developing the interview questions structure and questions, in addition to fine-tuning the conceptual framework.

The data which was collected from local Oil & Gas projects, added to the database of factors collected from research papers and the internet and ascertained the research assumption that the factors are almost identical without much dependency on the location of project. The data which was collected from the experts during the questions piloting and survey were specific to Oil & Gas, added value to the collected documentary data and conducive to analysis of the reasons behind their occurrences. In fact, in some cases, it was sort of filter and validation of the documentary data. Conducting focus groups to validate the factors and developing the conceptualize framework assisted in "explaining 'how & why' certain outcomes might happen rather than what those outcomes are" (Denscombe, 2007). This will facilitate the generation of non-numeric and numeric data uncovering underlying concepts, motivations, relationships and factors which is necessary to answer the research questions and achieve the stated aim. Therefore, it leans toward the mixed method since this approach appears more suitable to the study as the approach cannot be definite in adopting either quantitative or qualitative approaches. Figure 4.7 below shows the Exploratory Sequential Mixed Method Design steps.

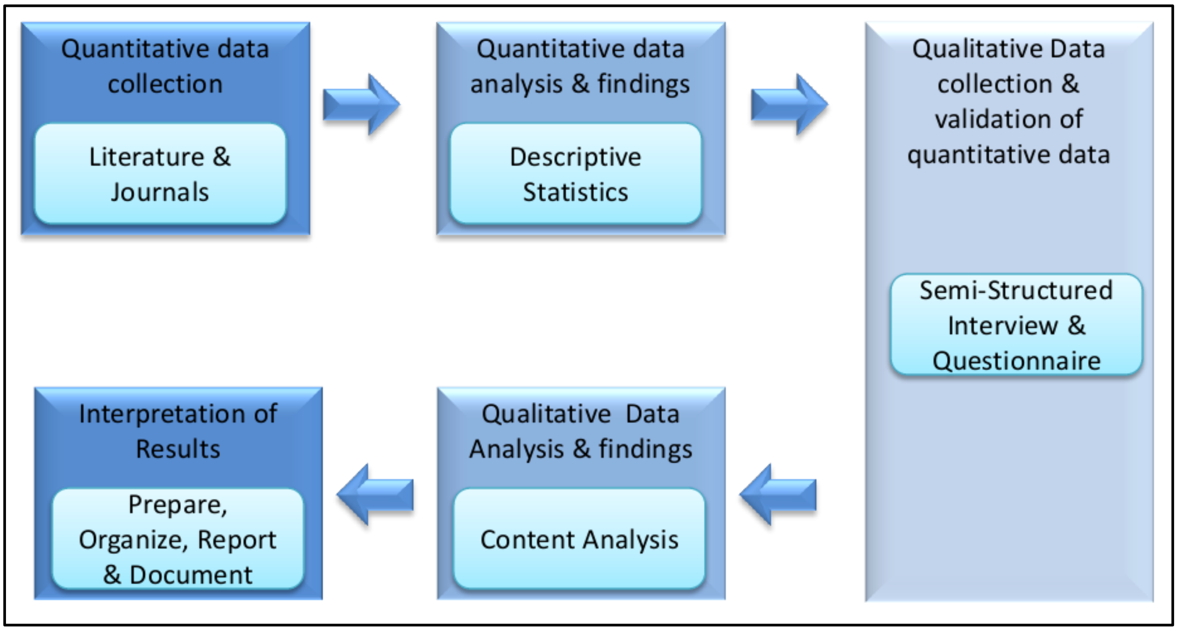


Figure (3.9) Sequential Mixed Method Design
Source: Adapted from Creswell (2014)

3.7 Research Strategy

The research strategy is defined by Denscombe (2010) as a plan of action, process or design lying behind the choice and use of particular methods. It links the choice and use of methods to the desired outcomes. The research strategy can be adopted to inform the methods, techniques, procedures or instruments by which the information will be collected and analysed (Crotty 1998). It is assumed that no particular research strategy is inherently superior or inferior to the other; therefore, it can be quite possible to adopt a combination of the strategies (Saunders et al., 2012). In this research, critical data analysis then using case study strategy was opted by the research.

There are various research strategies that could be employed in any research. Some commonly used research strategies identified from publications such as Creswell (2014), Saunders et al. (2009), Denscombe (2010) and Yin (2009). These include survey, experiment, case study, ethnography, archival, grounded theory and action research (see appendix 1). Yin (2009) as shown in the below table, addressed strategies that could be the appropriate based on the type questions modelled, control of behavioural events and focus on contemporary events. Furthermore, Robson (2011) observed that the type of questions and contextual settings of a research has a major influence on the type of strategy that would be best suitable to be adopted.

This research has adopted a case study strategy as best suitable based on the type of question developed, approach and knowledge claimed as well as the level of investigations required to validate the factors behind the poor performance of the Oil & Gas industry along with the conceptual created framework in order to achieve the mentioned aim and objectives. So the factors which were identified from the past researches and industry data available from various sources will be validated by conducting case studies and interviews with selected key stakeholders from past projects to capture their views and responses to selected and pre-qualified questions. Key project stakeholders, those who have wide and extensive experience in the Oil & Gas projects and can understand the factors behind the delays and cost overruns in Oil & Gas projects will be interviewed. The developed framework will be validated by the interviewees in order to gather the framework constrains and understanding by others.

Strategy	Form of research question	Requires control of behavioural events	Focuses on contemporary events
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes/No
Archival analysis	Who, what, where, how many, how much?	No	Yes
History	How, why?	No	No
Case study	How, why?	No	Yes

Table (3.2) - Research Strategies
Source: Adapted from Yin (2009)

3.7.1 Case Study

The case study as a strategy that involves the empirical investigation into specific present happenings within a real life context using multiple sources of evidence such as interviews, observation, document, artefacts and questions which form the basis for scientific generalizations (Yin, 2009). Wedawatta states that the technical characteristics included in Yin's (2009) definition of a case study deals with a technically particular situation which depends on multiple sources of evidence, and benefits from previous development of a theoretical framework to guide data collection and analysis (Wedawatta, Ingirige & Amaratunga, 2011). It also involves the extensive study of a phenomenon of interest to gain understanding on the dynamics that exists within a specific setting (Collis & Hussey, 2003). This in-depth study of a phenomenon would not have been revealed through a research strategy that considers large samples. Thus case study is mostly adopted in exploratory researches although can be applicable to descriptive, illustrative, experimental and explanatory research to answer research questions on how, what and why. One of the main great advantages of case studies compared with other strategies follows from its strengths to collect multiple sources and chain of evidence which allows for triangulation of evidence from different sources to corroborate the same fact or finding, which means that both numeric and non-numeric data can be used. It is also useful for trying to develop and test/validate models by using them in real world/organisation situations (Arif, et al., 2012). Hence case studies are flexible to be adopted in quantitative, qualitative and mixed method research designs (Yin, 2009).

A case study could be a single design where a case is studied based on unusual nature as a revelatory, extreme exemplar, or opportunities for unusual research access. It could also be a multiple case study where the interest is unequivocally on the phenomenon of which the cases are just examples (Thomas, 2011). While a single-case study can richly describe the existence of a phenomenon, multiple-case studies typically provide a stronger base for theory testing or building (Yin, 2009). Thus a multiple case study enables broader exploration of research questions and theoretical elaboration. This is attained by comparisons of an emergent finding, which support the same theory, and allows for replication. This will typically yield more robust, generalisable, and testable theories than single-case study designs (Yin, 2009 Saunders et al, 2012). Although the reason for case studies is mainly on analytical overview within the context for which it has been studied than statistical overview.

This research has adopted a similar way of processes and procedures to reach the final techniques of data collection and analyses, where the research philosophy stand point is justified, which approach is needed, (quantitative, qualitative, or mixed methods) and then the research approach has identified the best data collection techniques and methods. This research selected case study since case study focus is project key stakeholders whether individual, such as project managers, engineering manager, planning manager or small group such as contractor staff, client staff, manufacturing staff, also the case study is able to conduct a comprehensive analysis since three cases will be looked at and this will have provided a detailed analysis. Also the case study will identify various project various project variables like schedule, design complexity and stakeholders to be studied and interviewed. This explains why the survey was put aside since although it is an efficient means of gathering large amounts of data, it will be anonymous in nature and with no focus on key stakeholders. Feedback could also be left incomplete since no face to face discussion happened, and sometimes the write up and instrument wording can bias feedback and drive the result in one direction or another. Details might also be omitted compared to the case study where the group is selected thoroughly.

The case study allowed the researcher to go very deep in the project practices and the strategies then addressed the delay factors which have impacted the project performance and delivery. This allowed to validate these factors along with the strategies were practiced; the case study also validated the conceptual framework. The survey allows the research to develop specific questions related to the collected secondary data and validated them with key expert stakeholders and then listened to their views and feedback, whether they agree with these factors or disagree in addition they have the chances to add or delete and valuable or not related factor, also they will have the chance to express their views in the framework and whether they can improve it or fine tune it.

Adopting a case study strategy usually involves the determination of a unit of analysis for which variables are studied, data is collected and analysed (Saunders et al., 2012; Collis and Hussey, 2009; Yin 2009). The unit of analysis refers to the level of what or who the research questions seek to address (Yin, 2009). It is the entity about which data will be collected and generalisation made. For example, if we collect data about the individual, we can only draw conclusions about individuals. If we collect data about the performance of the project team then generalisations of the findings would be to the project team (Yin, 2009). Therefore, correctly identifying a study's unit of analysis is driven by our concern with minimizing errors when drawing conclusions based on our research. Yin (2009) identified the unit of analysis as the case itself. Yin (2009) and Thomas (2011) further pointed out that the unit of analysis can be holistic when the case is studied as a whole requiring only a unit of analysis being studied or an embedded unit of analysis where other subunits are investigated to support findings of the main unit of analysis.

In relation to this research, it is expected that exploring the current practices of Oil & Gas industry and the current adopted execution strategies in the projects with the poor performance of this industry will necessitate in-depth investigations on how the IPD will facilitate the improvement of the poor practices of Oil &Gas. Thus such investigation will require information from the key stakeholders and their feedback. The feedback and answers will be based on their experiences and perspectives current factors, current execution strategy, project stages, and main factors behind the Oil & Gas project poor performance. From this perspective, the framework and IPD principle can then be developed and validated.

This reveals that this research is an investigation into a contemporary event focused within a contextual bounded area (study scope) and requiring no influence or control of behavioural patterns and attitude of those expected to participate in the study. It is a research on a natural occurrence which investigates relationships and processes and not aimed at looking for statistical generalizations.

It is a study that requires in-depth investigations towards developing a conceptual model (theory). Based on the above review, in the bid to develop and validate the conceptual framework to be implemented in the Oil & Gas project to improve its performance and practices, therefore the ‘case study strategy is seen most suitable and adopted for this research based on the appropriateness to provide a platform for such in-depth investigations.

The participants of this case study will be key players in Oil & Gas projects, such as client (owner), FEED Designer, Contractor, Manufacturers, Client operation and Maintenance team and others such as sub-contractors. From each key stakeholder the researcher has selected those who have a key decision-making role in the project with major project influence. To make the results and data more robust, three case studies were selected and these case studies have been picked up based on their poor performance and one for its good performance.

There are various models presenting how data can be gathered, collected and analysed in a case study. These typical models could adopt the quantitative approach which should employ quantitative analytical procedures using questions or empirical experiments and numerical analysis in a single research to answer the research questions. It may also use and adopt a qualitative design which employs a qualitative analytical procedure using interviews and observations and non-numerical analysis in a single research to provide answers to research questions. In other cases, it could be a mixed method which employs both qualitative and quantitative analytical procedures. As stated under the mixed case section, this research has been rationalised by adopting the mixed case approach as the most appropriate to adopt the mixed method design in the context of this research.

Mixed method design for case Study strategy: Denscombe explains that the mixed method combines alternative strategies within a single research (Denscombe, 2010). It allows for both quantitative and qualitative data to be collected and analysed in any research. Using a mixed method strategy could develop a strategy in its own way or it may be included within another research strategy as in the case of adopting a case study design in which a number of different methods are embedded (Brannen, 2005). Such is the case adopted in this research. One of the advantages as a strategy is its ability to mix numeric and non-numeric data at different stages of the research process to improve quality, statistics and accuracy, and compensates the strength and weakness attached to single approaches. According to Denzin (1970 in Collis and Hussey 1998), the mixed methods approach enables triangulation, which can overcome the potential criticism of sole methods. Mixed method designs for data collection and analysis could be classified as basic or advanced designs presented in a notation system or by procedural diagrams (Creswell, 2014; Creswell and Plano-Clark, 2011). The basic designs include concurrent, sequential and exploratory while advanced designs include embedded, transformative and multiphase.

As no single data collection technique could have assisted in achieving the desired level of accuracy of data for this research and also since there was a time constraint preventing for going for more elaborative approach, the researcher had decided to adopt a mixed method for data collection. Creswell (2003) "states four decisions to be made to select the right mixed method for research which are listed as, What is the implementation sequence of the qualitative and quantitative data collection in the proposed study? What priority will be given to the qualitative and quantitative data collection and analysis? At what stage in the research project will the quantitative and qualitative data and findings be integrated? And Will an overall theoretical perspective (e.g. gender, race, ethnicity, lifestyle, class) be used in the study?"

There are six mixed method designs for case study strategy:

Convergent design is where quantitative data and qualitative data are collected and analysed independently during the same phase of the research process before they are compared or related (merged) to be interpreted.

Explanatory sequential design from the mixed method under the case study strategy occurs in two distinct but interactive phases. It involves the collection and analysis of quantitative data which has the priority of addressing the research questions, followed by a subsequent collection and analysis of qualitative data.

Hence the qualitative results help to explain the initial findings of the quantitative results.

Exploratory sequential design also occurs in two distinct but interactive phases. It involves the collection and analysis of qualitative data which has the priority of addressing the research questions, followed by a subsequent collection and analysis of quantitative data. Hence the quantitative results help to explain the initial findings of the qualitative results.

Embedded design involves when qualitative and quantitative data are collected and analyse within a traditional qualitative or quantitative design.

Transformative design is a case that is derived from a theoretical perspective and adopts quantitative and qualitative methods within the framework.

Multiphase design combines concurrent and/or sequential collection of quantitative and qualitative data set over multiple phases of the research. (See, Denscombe, 2010; Creswell, 2014; Creswell and Plano Clark, 2011).

Form the above six designs, this research follows the sequential design and mainly explanatory sequential design. The researcher started by reading the available resources in the Oil & Gas projects practices and current execution strategies, then moved further in the literature to identify the factors behind the poor performance of this industry, then the literature expansion continued to cover the IPD principles and approach. All of this was under collection and analysis of quantitative data from the literature, which was a priority of addressing the research questions, then followed by a subsequent collection and analysis of qualitative data by building the questions and conduct case study with the project expert stakeholders. Hence the qualitative results which were collected from the face to face interviews helped to explain the initial findings of the quantitative results.

On this platform, the researcher is of the view that an explanatory sequential mixed method design will be most appropriate as it will allow explaining the found factors, current strategies and obtain the detailed explanation from the key members. The explanatory sequential mixed case design decision was adopted in this research also draws from the views repeated by various philosophers in research such as Creswell (2014), Jogulu and Pansiri (2011) and Onwuegbuzie and Collins (2007) that such a design will provide the study with the platform, That provide answers for different quantitative and qualitative research questions posed bringing together a more comprehensive account of the inquiry, That use results from one method, to help develop the other method thereby creating synergy between quantitative and qualitative data, That explains, elaborate and clarify results from the quantitative phase toward the qualitative phase and last, That facilitates rationalized combinations which provide contextual understanding coupled with overview, external validity or broad relationship among variables through a case study.

This design is expected to facilitate answers to the research questions posed on what, why and how to achieve the stated aim and objectives of the study. It will enable the collection, analysis and interpretation of results from the quantitative phase, to build up initial qualitative findings to enable credible, validated and generalizable findings.

For this research, the data collection steps were discussed earlier under research strategy section. Three stages of data were collected using mixed method: first is Data collected from the currently published literatures (documentary data), second is Data collected from local experiences projects and third is Data collected from Oil & Gas experts in the piloting of the questions, the survey and the focus group workshop.

3.7.2 Research Methods

Research methods, as defined by Crotty (1998), are the techniques or procedures used to collect and analyse the data with the purpose of answering the research questions or hypothesis. Methods are rather detailed in the choices to be employed which have been informed by the strategy adopted. For example, it is not only an interview or participant observation rather what type of interview or kind of observation. However, the choice of the procedure for data collection and analysis will depend upon the purpose of the study, the route to achieving this purpose, resources available and the skills of the researcher (Creswell, 2014).

This section focuses on how primary data would be collected in this research. Data can also be classified as either qualitative or quantitative. Quantitative data includes those data that are termed numeric or countable data while the qualitative data are non-numeric data (Saunders et al., 2009; Collis & Hussey 2009). Therefore, a method of data collection and analysis implies the process or means by which data would be collected and analysed in a research.

3.7.3 Methods of Data Collection

Data definition as per online Oxford Dictionaries (2015) data are the facts and statistics gathered together for the purpose of reference or analysis. Whereas data relates to information, evidence implies data in support of questions or propositions (Thomas, 2011). Data can be sourced from both primary and secondary sources. Primary sources refer to those that are directly collected at field source while secondary data are those data collected from literature audio or video documents such as textbooks, journals, archives, annual reports, government published data and films (Saunders et al., 2009; Collis and Hussey, 2003). There are various methods to collect either qualitative or quantitative data. Common methods that have been popular and well recognized and identified from various literature includes; observation, interviews, questions, focus groups, protocol analysis, diary methods, and content analysis of documents to mention a few (Collis and Hussey, 2009: Dawson, 2009). Qualitative data collection methods are subjective and involve the collection of data based on the perception of participants to gather in-depth understanding into the study (Saunders, et al., 2012). Van Maanen (1983, in Collis and Hussey, 2003) further stated that it refers to “an array of interpretive techniques which seek to describe, decode, translate and otherwise come to terms with the meaning and not the frequency of more or less naturally occurring phenomena the social world” (Collis and Hussey, 2003). They also stated that the qualitative method of data collection enables in-depth information to be gathered on the study but may require more time and cost than those from the questions. However, the choice of a data collection method may depend upon the purpose of the study, the resources available and skills of the researcher. The qualitative data collection method involves obtaining data through direct observations and interviews (Saunders et al., 2012; Creswell and Plano Clark, 2011; Collis and Hussey, 2003). On the other hand, quantitative data collection methods emphasise on objective measurements and numerical analysis through statistical means – experiments and questions. According to Saunders et al (2009), questions are the most commonly adopted method of collecting data in social and management researches because of its numerous advantages.

From the above, the researcher has adopted and opted to have face to face interviews and develop question methods for data collection.

3.7.4 Questions

Questions are data collection methods in which the interviewees are asked to respond to the same set of questions in a predetermined order that will be interpreted in a same context by all the respondents. The interviewees are expected to provide answers in such predetermined order (Saunders et al., 2012). Denscombe (2010) further addressed that questions are employed to reach a large volume of interviewees in many locations. They are a common method of collecting quantitative data in social research and are apparently best suitable for use in descriptive or explanatory research. According to Saunders et al., (2009) and Dawson (2009), adopting a question is dependent on: the type of research questions, the number of questions to be asked, the sample size required for analysis, time availability to collect data and Characteristics of the respondents.

A question could be either closed, open-ended or a combination depending on the type of data required and may be administered through self, telephone, post or web-based (Collis and Hussey, 2009). The question method offers greater anonymity in terms of data collected, facilitates a large volume of information and could require less time and cost to conduct (Sekaran, 2006). However, this data collection method has been critiqued as having the disadvantages of low response rates, lack of detailed responses on a phenomenon and limited opportunities for spontaneous responses (Saunders et al., 2009).

In regards, the question method was adopted in this research because it would allow for the various findings from the semi-structured interviews under the identified themes to be structured into multiple questions organised in a predetermined manner and sent out to a wider sample of anticipated respondents. This is useful to gather quantitative data from a wide number of key project team organisations involved in Oil & Gas projects and they are direct relation and involvement with poor performance of this industry. The questions were designed with the aim of capturing the views of the interviewees on the identified variables. The question was divided into two main sections. In section A, the researcher validates the secondary data findings and obtains interviewees' agreement on these findings; section A also focuses in addition to the validation, to confirm the occurrence of these factors and the frequency of repetitions. Section B was on the Oil & Gas execution strategy, additional factors to be added to the literature findings, and the IPD principle toward Oil & Gas implementation. The final version of the question was based on revisions from previous pilot study. The question was tested using a pilot study.

Initial data on factors for various projects were collected from wide range of literature available through research database channels. This database was exhaustive and data was recorded in separate worksheets with references marked to the authors.

The data was filtered, grouped and analysed on several criteria for grouping such as Delay Factor occurrence phase, Delay factor impact phase, Discipline/Responsibility etc. this data was further plotted in graphs to identify the frequency of occurrence and grouped delay factors were selected for further data validation by next method.

Local project experience was added through lessons learned and sessions conducted for projects executed in the last 5 years in the region which is applicable to the Oil & Gas industries. The same filters were applied to these lessons/delay factors captured in these sessions and the data captured from the secondary sources was then compiled into sequential format of question along with the lessons/delay factors captured from local experience and piloting was done to validate the question.

3.7.5 Questions Design

Since the subject of the research and the questions asked in the question are technical, it requires specialized participants. The researcher has chosen face-to face interviews with each respondent and recorded their responses. With this choice, it is expected to deliver the questions to the right participants, and get a high response rate and higher understanding of the question by the interviewee and better focus of the interview and quality responses from each interview.

The questions have followed the five principles of designing questions, stated by Easterby-Smith et al., (2012) these are:“Each question should express only one idea, Avoid jargon (expressions) and colloquialisms (informal expressions), Using simple phrases, Avoid the use of negatives and Avoid leading questions.” Smith et al., (2012).

Also, the measurement scales used to measure the responses have been built to measure attitudes and opinions, as it is necessary at this stage to filter out all the recommended regulations. The scale has been structured as follows:

Each degree of agreement has been given the following initials: Agree (A) & Disagree (D). The question was divided into three sections. One objective questions and two subjective.

3.7.6 Questions Piloting

A pilot test is useful in the refinement of the questionnaire to eliminate problems in answering and recording the data, enabling the researcher to obtain some assessment of the questions’ validity (i.e. enables content validity) and likely reliability of the data (Saunders et al., 2009). Thus, in order to develop the questions in line with the objectives and to improve the feedback, it was decided to pilot the questions and receive a feedback from the expert participants, subject matter experts who assisted the researcher for piloting gave several valuable suggestions regarding re-grouping, re-sequencing and adding/deleting other delay factors for the next stage of interviews.

3.7.7 Interviews

This method of data collection involves a purposeful conversation between two or more participants in which one, referred to as the interviewer, asks clear and concise questions while the other(s), referred to as the interviewee(s), listens attentively and willing responds to the questions asked (Saunders at al., 2012).

The interview method allows the researcher to collect data interacting person to person between two or more individuals with a specific purpose in mind (Sekaran, 2002). Thus, interviews can be most appropriate for complex situations, visual demonstrations are required and instant feedback is desirable (Ranjit, 1999).

The interviews advantages are: Facilitate the collection of in-depth information and Provides a platform to obtain explanations on questions/further clarifications (Ranjit, 1999).

Interviews are best suited where; A study focuses on the meaning of particular phenomena from the perspectives of those involved and Individual historical accounts are required of how a particular phenomenon developed.

Interviews have been classified as structured, semi-structured or unstructured and could be conducted on a face to face, via telephone or internet and can take the form of one to one, groups or focus groups or via the internet (Denscombe, 2010). Subsequently, semi-structured interviews have been described as the most common employed in social and management research because it is more formal than an unstructured interview and allows in-depth investigations across a number of specific topics around which to build the interview (Saunders et al, 2009; 2012).

3.7.8 Semi-structured Interview

Thomas (2011) explained the semi-structured that gives the best of both worlds since it is based on a list of themes rather than specific questions and the researcher has the freedom to follow up on points raised by the interviewee where necessary. Therefore, the list of themes developed by the researcher as a form of interview schedule or guide is linked to the research questions and objectives. In addition, it enables the use of a theoretically informed interview pro-forma to build structure into the data collection process (Fellows and Liu, 2008). Due to the degree of structure in its implementation, it allows at least all interviewees to receive some questions in common and gives the researcher the room for flexibility. Semi-structured interviews have been identified as the most common type of interview conducted in small-scale social research because of its advantages. Semi-structured interviews were employed to allow in-depth exploratory to validate the factors in the Oil & Gas industry and other key factors to be added. It further facilitated the understanding behind the poor performance and how the IPD will facilitate the improvement.

Post-piloting, the final interview questions were formulated and individual interviews were conducted face-to-face with the interviewees who had volunteered to support the research and agreed to the ethical approach of the research. The interview was designed to obtain the following results: Validate the factors and get subject matter expert acceptance for the delay factors identified from literature, Identify the factors which can be resolved early through mitigation measures or by involving external stakeholders (EPC contractor, manufacturers, specialist consultant/sub-contractors), Identify the phase of occurrence for each factor identified, Identify the responsible stakeholder against each factor, Understand the participant background and record the variables with respect to the participant age, nationality, experience, country of work, etc, Understand participant view about delay factors, the reasons for project poor performance and dependencies to other variables and last to Capture inputs from participants (subject matter experts) for further suggestions for assisting in understanding a robust framework to address majority of the factors and gaps and drawbacks in existing project execution strategy.

Questions are selected and structured to examine whether the selected research delay factors were identified in past projects and what other factors may impact project performance. In addition, stakeholders will be interviewed to validate the proposed framework for effectively resolving the selected delay factors.

3.8 Method of Data Analysis

Data collected can be analysed using different procedures depending on whether the data is qualitative or quantitative.

3.8.1 Qualitative Data Analysis

Procedures which allow for words, text and images to be transcribed and coded are usually employed in qualitative data analysis. Some of the methods for analysing qualitative data include content analysis, thematic analysis, discourse and narrative analysis and grounded theory as shown in Table 3.3. All these methods have their strengths and weaknesses, and content analysis has been identified as one of the commonly used analysis methods because of its main advantage as a technique to make replicable and valid inferences from text to context of use (Krippendorff, 2004).

S.No	Qualitative Method of analysis	Approach
1	Content analysis	Content analysis is a descriptive approach systematically coding and categorizing approach used for exploring large amounts of textual information unobtrusively to determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication
2	Comparative analysis	closely connected to the thematic analysis however in these case data from different people are contrasted until no further or new issue arise
3	Discourse analysis	Based on speech- how people talk what has made them talk. Speech is analysed as performance rather than the state of the mind.
4	Grounded theory	analytical procedures involve the coding and categorization of data collected with the aim of deriving concepts and theories from meanings within a data.

Table (3.3) Qualitative Method of Analysis
Source: Krippendorff (2004), Mills, et al., (2010) Dawson (2009), and Saunders, et al. (2012).

Since the researcher intends to confirm the key critical factors behind poor performance of projects and how the IPD will facilitate improvement, there is a need to derive understanding via concepts/themes that relate to the investigations from the views, attitudes and opinions of the interviewees and stakeholders. Content analysis was therefore adopted to analyse the qualitative data collected. This facilitates both conceptual and relational analysis of the data, which helps to establish the existence and frequency of concepts most often represented by words or phrases in the data. It also enables further examination of the relationships between concepts. A sequential procedure for content analysis (Elo and Kyngäs, 2008) was adopted for this study, involving preparation, organisation and reporting. The researcher started the interviews by confirming the quantitative data and then moved to qualitative analysis to support IPD implementation. This helped to explain how the framework can be implemented and what challenges may occur. The quantitative analysis showed the percentage of interviewees confirming each poor performance factor and agreeing about the phase in which they occur and the responsible stakeholder.

3.8.1.1. Stage one: Preparation

This involves transcribing the data and taking brief notes where relevant information was found. Familiarizing with the data collected is also important for the researcher to gain detailed insight of the whole information found in the data related to the concept and context of the research through reading the transcripts several times (Denscombe, 2009). The semi-structured interviews were conducted and notes (transcript) were taken from each interview. The process of the transcription allowed the researcher to gain insight into the data collected (Vaismoradi, Turunen, & Bondas, 2013). The thoughts and reflections from one interview on some occasions were considered and used in the conduct of the subsequent interviews though with some level of caution. Subsequently, through several readings of the noted and findings (transcripts), the researcher gained detailed insight into the content of data collected identifying areas of relevant information in the data, this improved the overall interview sessions.

3.8.1.2. Stage Two: Organisation

This is a major process in qualitative data analysis. It involves identifying common concepts/theme, assigning appropriate descriptive codes and collecting codes under potential subcategories/subthemes or categories/themes, and comparing the emerged coding's clusters together and in relation to the entire data set (Denscombe, 2009). Concepts were grouped into major and sub-concepts in a way that offers a description of what it is about and ascertained whether some of the major themes and or subthemes could be merged carefully identifying possible links. According to studies by Vaismoradi, Turunen and Bondas (2013), codes can be manifest which entails what is physically present and countable in the data or latent contents, which could be structural meanings underlying the data.

There are two main approaches for coding known as deductive and inductive with the former based on predefined categories based on literature findings or theories and the latter emerging from the primary data. However, it has been suggested that the approaches could be combined in a research for comprehensiveness (Miles & Huberman, 1994). Therefore, for this study, this approach is adopted by predefining some codes through literature background and allowing new codes to emerge from the text itself.

3.8.1.3. Stage Three: Reporting

This involves reporting the analysing process which results through models, conceptual systems, conceptual map or categories, and a story line. Following the bulky nature of the text, MS Excel formula and equations are used to facilitate the analysis procedure of the qualitative data collected and to provide the figures.

To further map and illustrate the identified relationships within various Oil & Gas factors relating to a concept investigated, the Interpretive Structural Modelling (ISM) technique is utilised. A diagrammatic illustration of the qualitative data analysis procedure is reflected below:

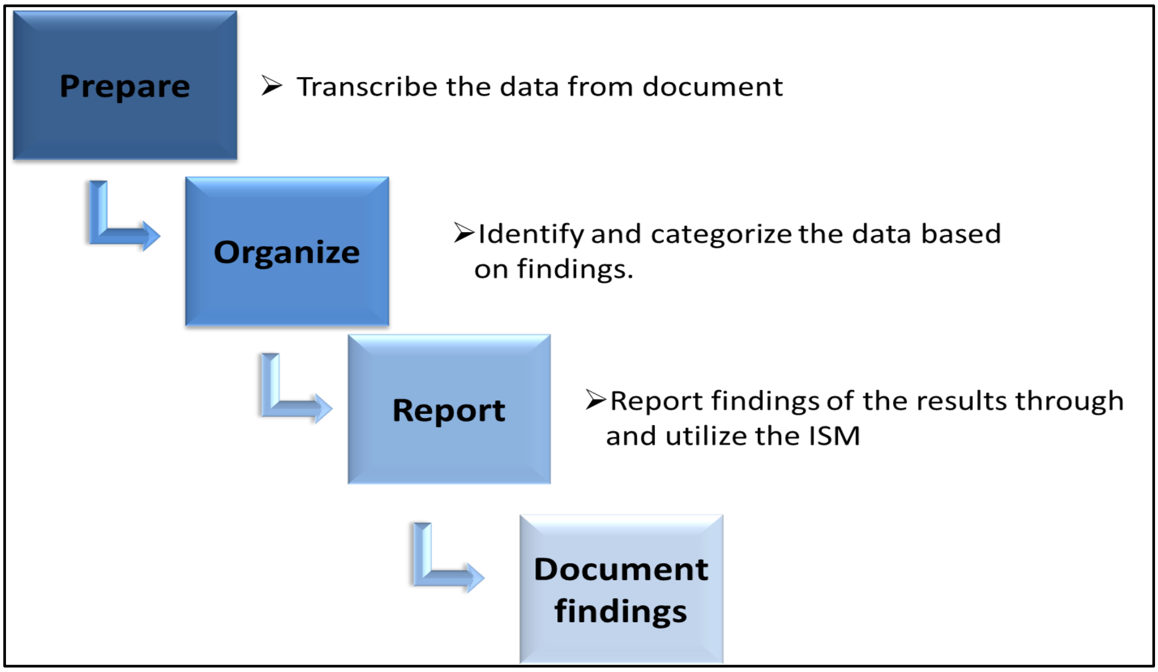


Figure (3.10) Qualitative data analysis procedure
Source: Krippendorff (2004), Mills, et al., (2010) Dawson (2009), and Saunders, et al. (2012).

3.8.2 Quantitative Data Analysis

Quantitative data and statistical procedures are used for analysis such as descriptive and inferential statistics to draw conclusions about the data collected to the population (Collis and Hussey, 2003). Quantitative data statistical analysis has been categorized into descriptive and inferential statistics (Field, 2013; Pallant, 2013; Dawson, 2009). In analysing the data collected via literature, both descriptive and inferential statistics would be conducted.

The descriptive analysis is based on the measure of central tendency and distributions and used to describe the data collected. The common types used are (Field, 2013; Pallant, 2013; Dawson, 2009): Frequency, Percentages, Mean and Median standard deviation.

As described by An Gie Yong and Sean Pearce (2013), factor analysis is a method to study data by summarizing the available data so that the inter relationships and patterns can be studied. It is basically regrouping variables into limited clusters on the basis of common variables. (An Gie Yong and Sean

Pearce, 2013) Mathematical procedures are used for simplification of interrelated measures to discover patterns in the set of variables (Child, 2006).

In this research, the quantitative data was used to study the poor performance factors identified, and classify them into groups such as design factors, planning factors, project management factors, procurement factors, contract factors, resources factors and other. The factors were also grouped by the phase in which they occur, i.e. in which phase of the project the factor appered and also which stakeholder was behind its appearance. This quantitiative data was extended during the case study to cover the interviewees' answers to the questions. The case studies' interview questions (Part A) are mainly associated with categorical data and thus descriptive statistics using frequency and percentages will be most appropriate to analyse, describe and present the findings. The percentage of interviewees agreeing and confirming the poor performance factor is required along with the percentage of interviewees confirming the occurrence phase of each factor and the stakeholder responsible for its occurrence. This descriptive data was extended to find the percentage of interviewees confirming that the framework could help improve project performance and aware of IPD principles. This is also applicable to some questions in part B, on interviewees' level of agreement, which is associated with categorical data. Instead of Statistical Package for the Social Sciences (SPSS 20) software, the researcher used MS Excel tables to present the statistics and draw the figures.

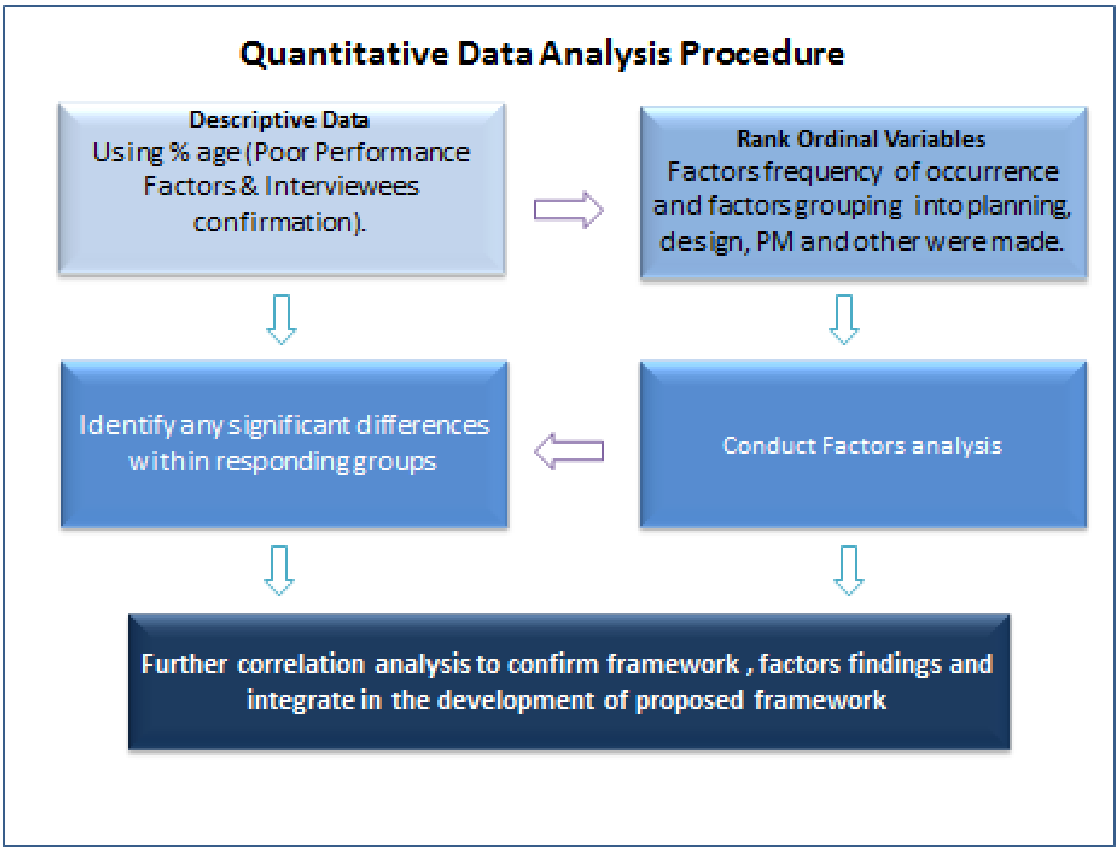


Figure (3.11) Quantitative Data Analysis Procedure

3.9 Interpretive Structural Modelling (ISM) approach

Interpretive structural modelling (ISM) is an established methodology to identify relationships between specific topics and items, in order to define a problem or an issue. This approach has been widely used by various researches to represent the inter-relationships between various elements related to the same problem and topic. The ISM approach was begun by identifying variables, which are applicable to the problem or issue (factors in this research). Then a contextually applicability subordinate relation is selected. Once the contextual relation is selected, a structural self-interaction matrix (SSIM) is developed based on pairwise comparison of variables (factors in this research). Then SSIM is converted into a reachability matrix (RM) and its transitivity is verified. Upon transitivity embedding is completed, a matrix model is developed and produced. Later, the partitioning of the elements and an extraction of the structural model called ISM is developed. In this research, the same approach will be used to find relationships between the poor performance factors as variables, which have led, drive or dependent to poor performance of Oil & Gas project delivery. The same factors (28 factors were identified) and the contextual relations between each factor will be made and then entered self-interaction matrix to be developed based on each pairs comparison of factors. The same matrix will be converted to into reachability Matrix and transitivity is checked then matrix model is produced.

Chapter 4. CRITICAL PROJECT POOR PERFORMANCE FACTORS AND DEVELOPMENT OF INITIAL FRAMEWORK

4.1 Introduction

Data was collected from literature available from various online sources and libraries. Data was collected on subjects related to integrated project delivery, major factors behind poor performance in the construction industry, poor performance factors in Oil & Gas Projects, current Oil & gas projects execution strategies and IPD approach and principles.

An initial framework will be developed to address the method of integrating key stakeholder and how the IPD principles will be conceptual. One of the objectives of the initial framework is to overcome the current common problems of project execution strategy under a design-bid-build delivery method and, where late integration among key stakeholders are occurred, such as contractor, major/minor manufacturers, subcontractors' involvement begins after completing the FEED design. This is one of the reasons why contractors, major/minor manufacturers and subcontractors are adding more costs in order to compensate for the risks owing to the incomplete information available during the bidding. Bringing all the stakeholders, such as interested contractors and vendors, to participate during the FEED design phase will mitigate majority of project uncertainties and expand their scope understanding and technical knowledge. Contractors and manufacturers will also have the opportunity to understand the design basis and challenge the design since both design (FEED) consultant and owner will be together with them during design and technical clarifications without any commercial implication. This will enrich the technical scope of the work and reduce the number of assumptions, which are assumed by all parties during subsequent phases. Involvement of all stakeholders as early as in the design phases also will allow the stakeholders to verify the constraints and market challenges from the execution, construction, delivery at site, installation, testing, commissioning and operation and maintenance, which usually happens at late phase of the execution, i.e. during a detailed design phase after the construction contract award.

In this chapter, the researcher based on the research methodology structure, the literature data will be analysed and phase groups, category of factors and stakeholders of each factor will be created in order to understand where and when the influential factors occur, which category is critical and has major impacts then who is responsible from the stakeholders on each factor.

4.2 Critical project Poor Performance Factors

4.2.1 Critical Data Analysis Structure

Quantitative data and statistical procedures are used for analysis such as descriptive and inferential statistics to draw conclusions about the data collected to the population (Collis and Hussey, 2003). Quantitative data statistical analysis has been categorized into descriptive and inferential statistics (Field, 2013; Pallant, 2013; Dawson, 2009). In analysing the data collected via literature, both descriptive and inferential statistics would be conducted.

It was noticed during the data collection that limited papers are available relating to Oil & Gas project poor performance and delays. In addition, many factors were repeated and it was essential to expand the review to cover other sectors in order to regionalize the poor performance factors. Papers related to pipeline, power plant and utilities projects are considered to be of the same nature and field.

To further enhance the database and to find similarities to other industries, factors were added from general and infrastructure construction projects and lessons learned from previous local market projects. In was observed that several poor performance factors were common between construction projects and local lessons were learnt (ADCO, 2012); therefore, delay factors cited in the literature relating to general construction projects were included since they were occurring in Oil & Gas projects. This literature expansion has allowed enhancement and augmentation of the Oil & Gas delay factors. As a result, 29 papers were selected, which directly address poor performance factors encountered during the execution of construction projects. The selected papers presented research from many continents including North America, Latin America, Africa, Europe and Asia. All papers address major reasons for having project delays and cost overruns.

The research started tabulating the literature factors, once the factors were recorded, then it was observed some factors are repeated by other literatures, as a result the researcher decided to add the frequency/number of repetition of each factor, this is to understand the criticality and influence of each factor.

During the tabulation, some factors were found similar in the meaning but they were mentioned in different explanation, so the research kept these factors as a standalone then they were combined.

Factors once they were tabulated it was required to gather similar factors under related group, thus, the factors were group to their description to design related factors, planning related factors, communication related, project management related, contract related, construction related, resources related, governmental related and environmental related, this grouping helped to understand the size of each group and most critical group, where the group is repeated by various literature examples and repeated by other project.

The factors occurrence duration was tabulated in order to understand when each factor has occurred during the project phases. The researcher started analysing the factor literature explanation and refer each factor to the phase when the factor happened, i.e. if the factor happened during the design phase, tendering phase or during the execution and construction phase. This helped the researcher to realize that some factors occurred during more than one phase and they are repeated during the design and construction, this indicate their criticality and influence and they were repeated without attention from the stakeholders.

The tabulated factors also were analysed to identify the stakeholders behind their occurrence, this has helped to understand which stakeholder play major role in the project lifecycle and to understand if there are factors caused by more than one stakeholder or group of stakeholder.

Factors went further in the analysis and tabulated in terms if the factor can be discussed and resolved during any the phase of occurrence or the next phase

4.2.2 Data Analysis

As an initial finding, of the 193 prominent factors identified by Oil & Gas papers causing delays in Oil & Gas, power, utility and pipeline projects, 124 factors can be potentially addressed during early design (FEED). Of the 863 most prominent delay factors in construction identified, 393 can be potentially addressed by integrating the stakeholders early during the design. Of the resolvable delay factors during early design, some include: conflicts in drawings & specifications, inadequate or improper planning, outdated standards, over designs, incomplete designs, lack of communication between parties, conflicts/disputes, incomplete or inaccurate cost estimates, inappropriate overall organisation structure linking all project teams, etc.

When similar findings from all papers and authors were collated, the total number of unique findings was only 139. For example, additional works, change orders, contract modifications, multiple change orders, new scope additions, redesign & change orders, swift changes in contract specification and unavoidable changes during construction were grouped under a common header: change orders. Of these combined 139 delay factor groups, 90 can be eliminated during early design phase by implementing appropriate measures. Several findings fall under different area category, for instance, conflicts and disputes can occur due to improper communication between various entities, improper contract terms, improper design (which can lead to additional work not envisaged during early design or bidding), improper management and different nationalities of labourers.

Based on detailed analysis of the delay factors, it was understood that even though the delay due to one factor can occur at different phases of the project, it can be resolved by implementing proper mitigation measures during the early design phase (during FEED). For example, change orders raised during the procurement phase can be eliminated if material specifications are developed with early consultation with contractor and manufacturers i.e. if the specification is calling for materials not available in the market, contractors and manufacturers can provide alternative solution at an early phase and avoid anticipated delay and cost due to change order approvals. Change orders can also occur during the construction phase due to constructability constraints. If constructability is studied in detail during early design with contractor involvement, then delays and change orders can be resolved and eliminated early during the design.

All of the collected factors were consolidated, tabulated and categorized for further analysis and processing; the following criteria were considered and categorized for each factor:

Type of Projects. Oil & Gas, construction, power plants & energy projects, utility projects & civil infrastructure.

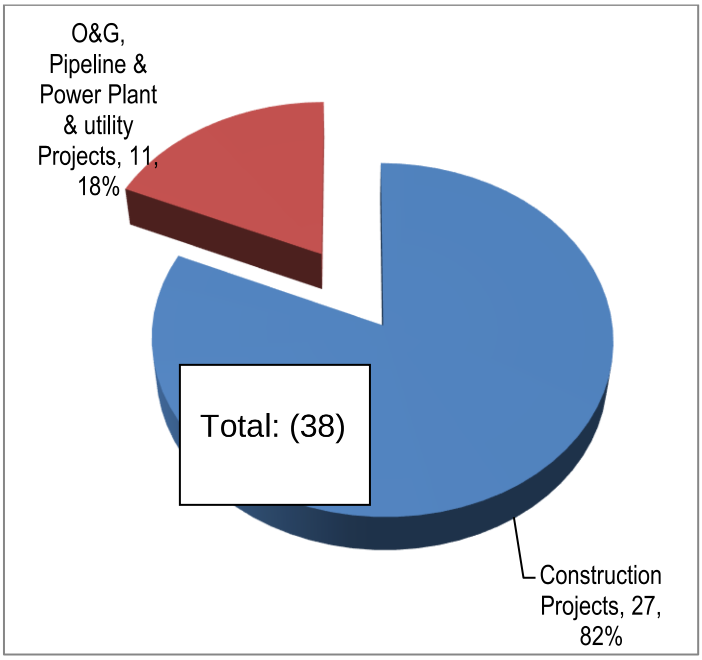


Figure (4.1) Literature Findings: Oil & Gas, Pipeline & Power/Utility projects Vs Construction Projects

This categorizing assisted the researcher to evaluate the current available poor performance factors for Oil and Gas versus general construction projects. It was found that there are limited Oil & Gas papers compared with construction and Infrastructure projects, leading the researcher to extend and enhance the data research and include local lessons learnt and include the construction projects.

4.2.3 Discipline, Phase or Occurrence

All factors were categorized based on their discipline, phase of occurrence or area that could be attributed to delays caused by planning, design, resources, contract, communication, environment, quality, management, regulation/ policy, & procurement areas. This categorization quantified the size of the factors related to each area, i.e. the size of poor performance factors related to all areas and which created most impacted. It was found that design, communication and planning represent a high percentage and have repeated factors in a majority of papers.

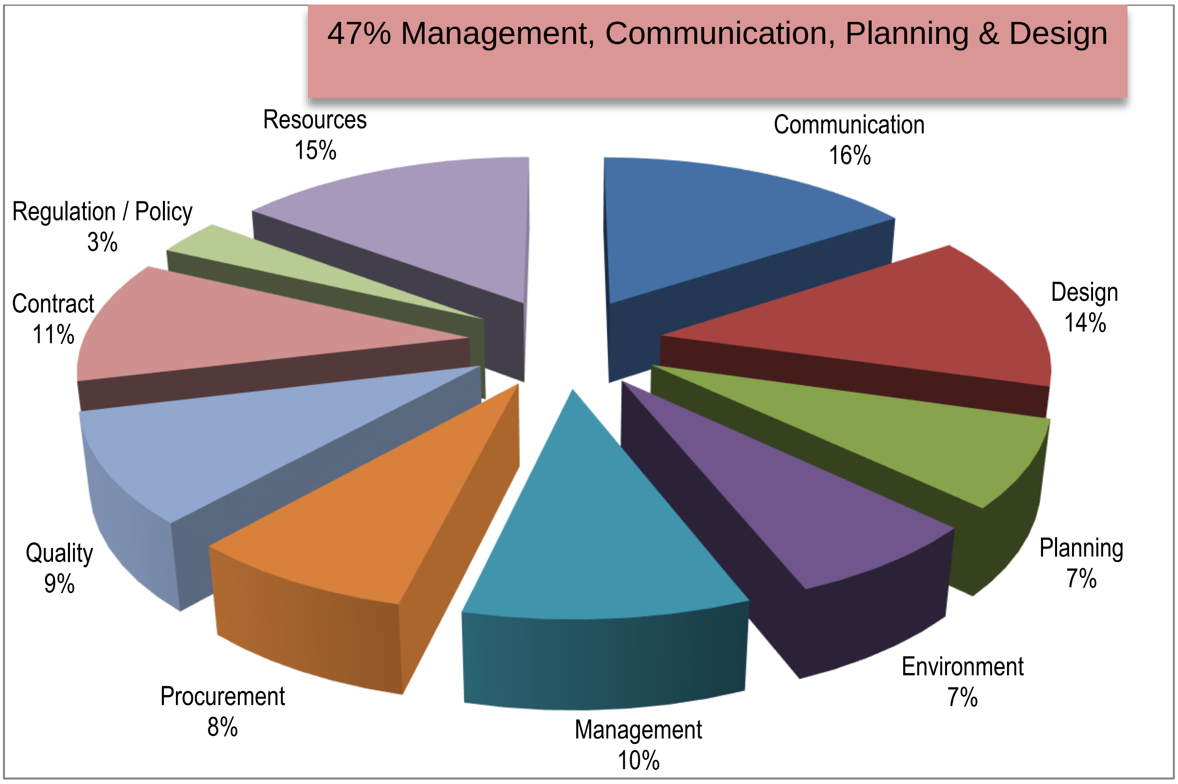


Figure (4.2) Category Wise Delay Factors – All projects

All poor management factors have been filtered/categorized into 10 major categories based on the discipline or area; such as Communication, Resources, Regulations and Policies, Contract, Quality, Procurement, Management, Environment, Planning and Design. It was recorded and noticed that some potential factors had occurred in more than one phase of the project, i.e. they have occurred during the conceptual design, FEED design, tendering phase, EPC detailed engineering or during the EPC construction phase and also related to different disciplines. It was thus decided to include them under each phase of occurrence and under each related discipline at the beginning data analysis and later during the analysis once each area and phase were recorded and logged, it was decided to present these factors in the most dominant area to minimize repetition and to provide distribution that is more sensible.

The most critical categorization was the disciplines categorization and which area each factor should fall under, from the ten mentioned categories. It was noticed that management, communication, design and planning represent the critical and biggest percentage of factors leading to poor performance. These four categories – management, planning, communication and design – were also found to represent the highest and critical categories which led the poor performance. Observations for the factors related to the Oil & Gas papers were carried out. Combining factors from various industries was not encouraged to ensure that thorough findings are recorded, therefore the researcher maintained their analysis independently during the analysis phase. Once the researcher moved to analyse the factors under the general construction papers, the result was analogous, i.e. the same categories were dominating the construction sectors. categorization was repeated for construction projects and then Oil & Gas and construction projects. The design, communication, management and planning delays were more frequent, and represent the higher number of factors leading to poor performance.

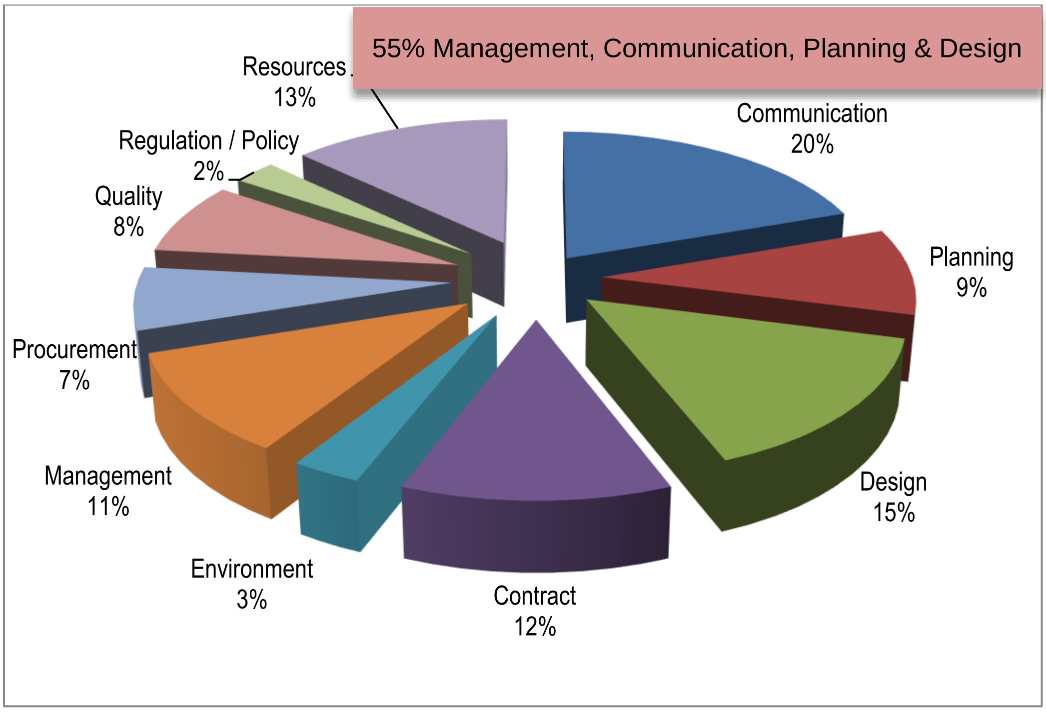


Figure (4.3) Category Wise Delay Factors – O&G, Power, Utility & Pipeline projects

Figure 3.3 above shows the category distribution and percentage of each category for the papers related to Oil & Gas alone. The four categories represent 55% of the total factors of poor performance and other categories. This includes Contract, Environment, Quality, Regulation and Policies, Procurement and Resources, which are sometimes related to a specific project, nature or region/location. Therefore, it was decided to focus on the key repeated factors and those that represented a high frequency.

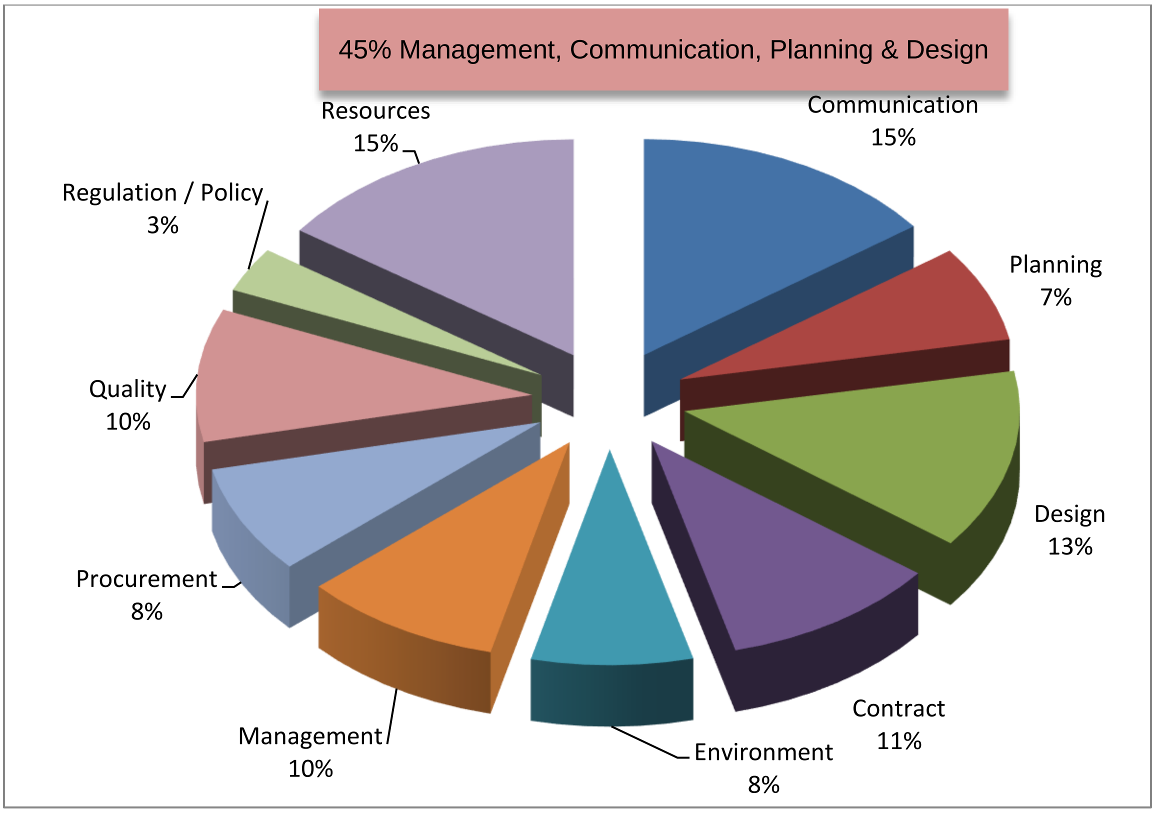


Figure (4.4) Category Wise Delay Factors –Construction projects

The same analysis was used on the factors related to general construction papers. Using the same categories, it was found that the four same categories – Management, Planning, Design and Communication – represent the high percentage of categories contributing to poor performance result. Some 45% of the total factors were related to these four categories. This encouraged the researcher to focus on these categories and consider them as the potential, critical categories for further attention. Other categories were less repeated and were related to specific reason related to that project or location or region.

4.2.4 Responsibility and Accountability

The factors were further filtrated based on the responsibility and accountability of the stakeholder, i.e. whether the factors were caused by owner/client, project management consultant (PMC), concept/FEED consultant, contractor, subcontractor, manufacturers, government, etc. This filter indicated the source and the most accountable stakeholder who contributed to the poor performance, as well as the size of factors related to each of the stakeholders, and which stakeholder holds the highest accountabilities.

It was found that the highest responsibility of poor performance falls under the contractor/subcontractors with 44% of the factors. The second tier of responsibility was the owners with 22% of poor performance factors; the third was the FEED designer with 11%. This finding shows that contractor arrival at the last phase of the project, i.e. the construction phase, lead him to miss many of the engineering details and previous detail due to late arrival in the project. It was also noticed that contractors' late arrival made a gap in communication with the owner, and this gap caused many factors due to misunderstanding of the owner objectives, requirements and engineering quality. The finding identified the value of the contractor as a potential stakeholder with the highest responsibility. Contractor late participation and the time gap between him and the design made is to bear all the risks. These risks are related to incomplete design work, unclear scope of work by the design and vagueness in the strategies. All of this led the contractor to bid with a risk factor, which was considered differently by each bidding contractor. A contractor could ignore this risk and not assign it a value or, or could provide high value for the same risk. The first option makes the awarded contractor suffer during the execution; the second option makes the contractor inflate the risk value and lose the opportunity. Neither option served the biding contractors. The factors, which were referred to the contractors, are approachable during the design phase and are executed during the construction, thus the lack of contractor involvement during the design phase led him to perform the project with risk and complete with late schedule, poor quality or higher cost.

The Stage Gate® model is widely used by organisations for executing Oil & Gas projects. In this model, check points are set in predefined stages to ensure that the minimum requirements to move to the subsequent stages are met and approvals are obtained. Though very effective in ensuring that the quality requirements are met thoroughly, this model is limited to the constraints of the delivery method that is used for the project, hence it does not assist in engaging the key stakeholders during the early design (Concept/FEED) stage for more detailed and precise design. EPC contractors and major manufacturers get involved at the execution stage and still the gap to involve them exists in this Stage Gate process, and the end user is involved during the start-up of the projects, this concluded that later contributed stakeholder suffer from this gap and event.

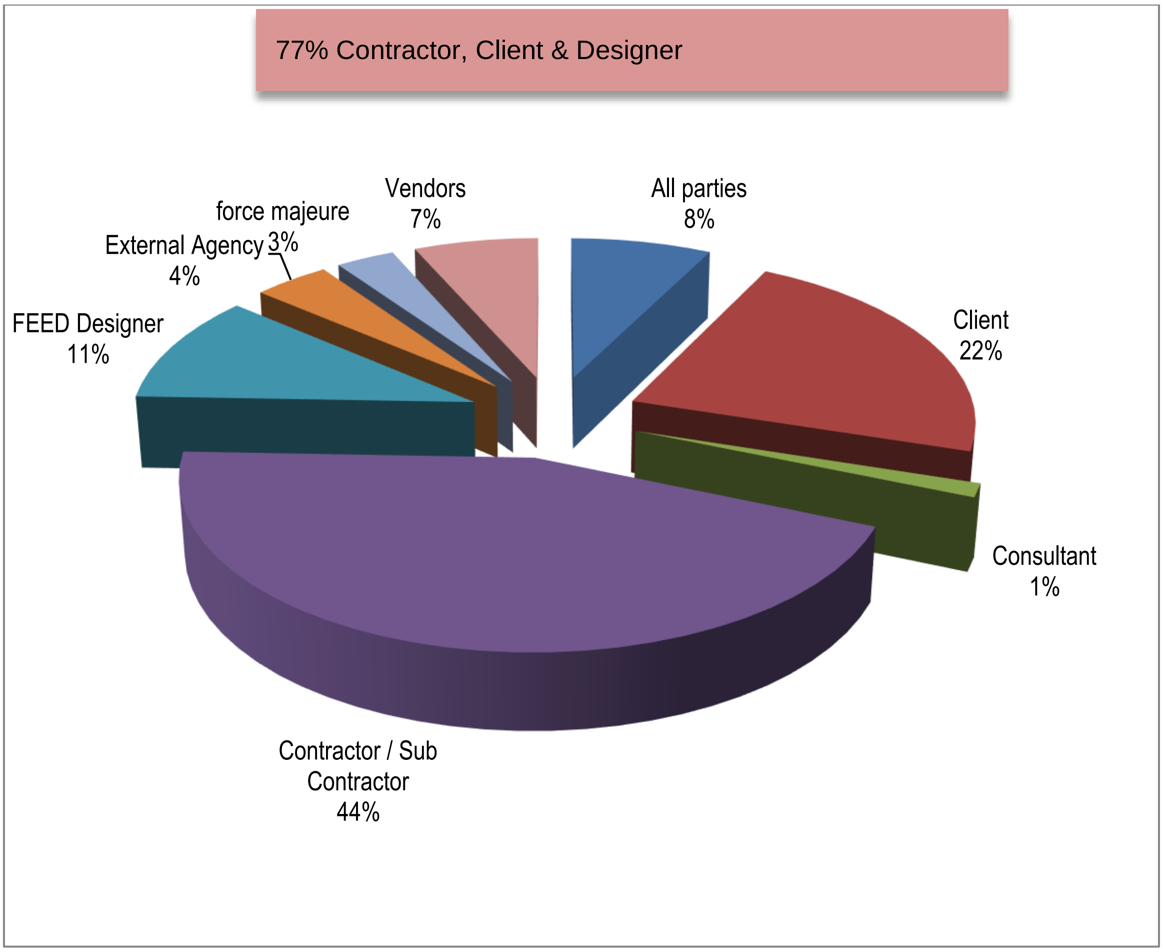


Figure (4.5) Responsibility Distribution for Findings from Literature

The graphs shows the key stakeholders in each project, despite the stakeholders vary from owner, designer, external agencies, contractors, subcontractors, third party consultancies, government, local authorities, however the three main contributor stakeholders with 77% accountability were Contractor, client and designer.

4.2.5 Occurrence Time

The occurrence stages/phases of each factor were also categorized based on occurrence time i.e. when each factor had occurred or when there was more than one phase/stage where the same factor was repeated and found. This stage is also used to find out which phase of the project has the highest number of occurrences, i.e. design, construction or concept.

It was found that the execution phase (construction) represented the highest delay occurrence followed by the Concept/FEED stage. The same was repeated for the construction project with similar outcomes, i.e. in construction projects, the highest number of delays occurred in the construction phase followed by the concept/design phase. All phases shown in the figures means that the same factor was found in various phases, i.e. it occurred in execution, concept/FEED design and during tendering.

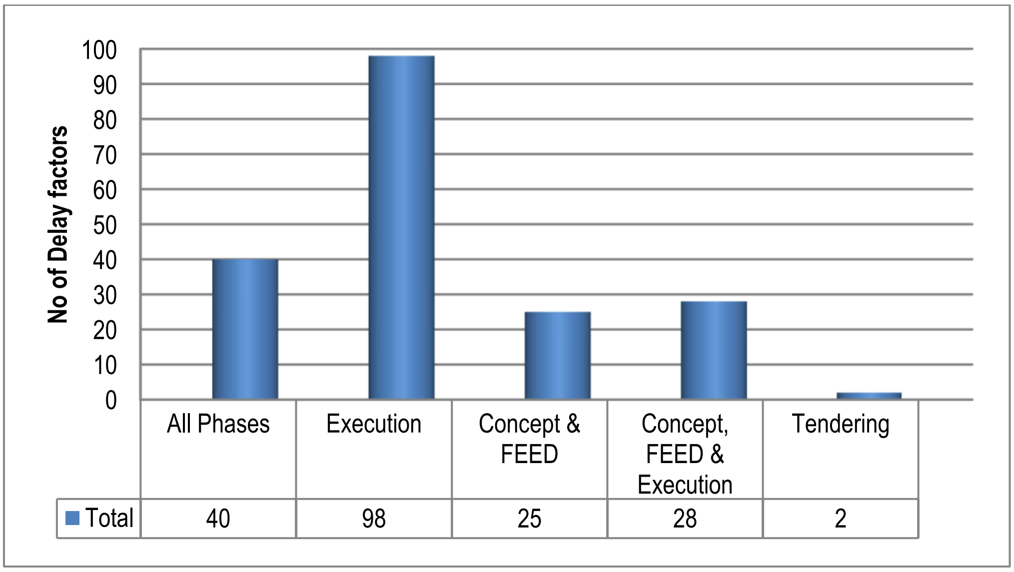


Figure (4.6) Delay Factors based on the occurrence time – Oil & Gas Projects

This graph represents the phase of each occurred factor in the Oil & Gas papers. The majority of the factors happened during the construction phase; this is due to the longest duration during the project lifecycle. This also shows that getting these factors looked at as early as possible could eliminate their occurrence.

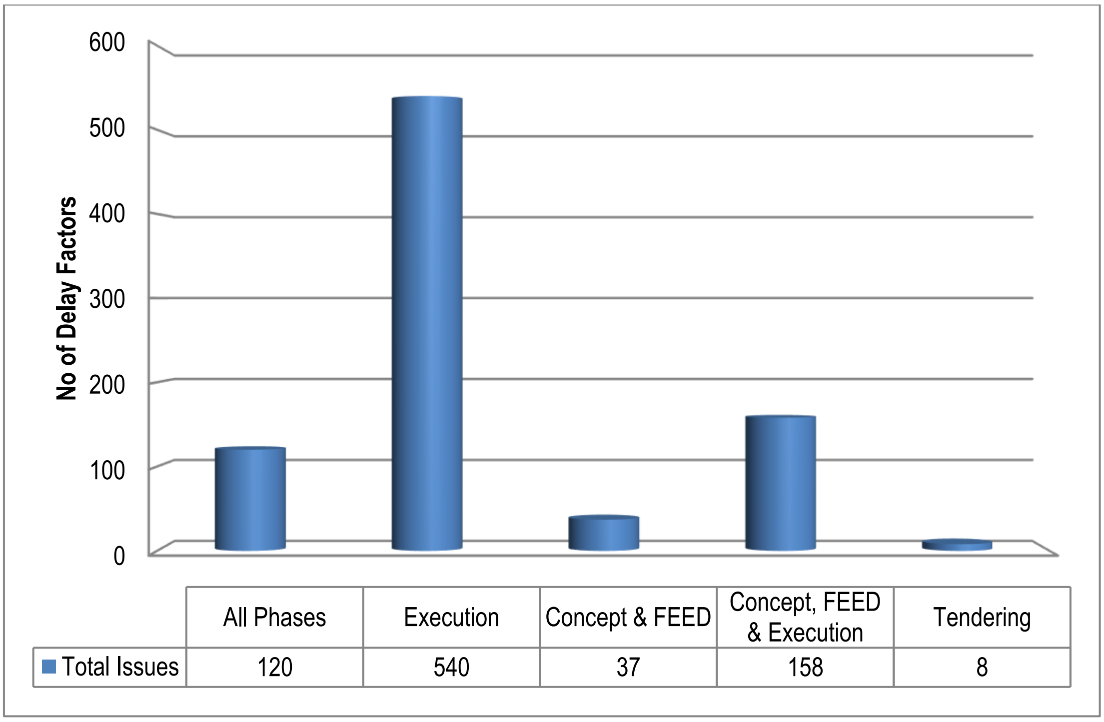


Figure (4.7) Delay Factors based on the occurrence time – Construction Projects

The same was analysed for the general construction factors, and the execution phase represents the key phase during the project life cycle where the majority of factors occur during this phase. This provided a clear finding that the lately contributed stakeholder is holding the highest responsibility and main contributor of poor performance.

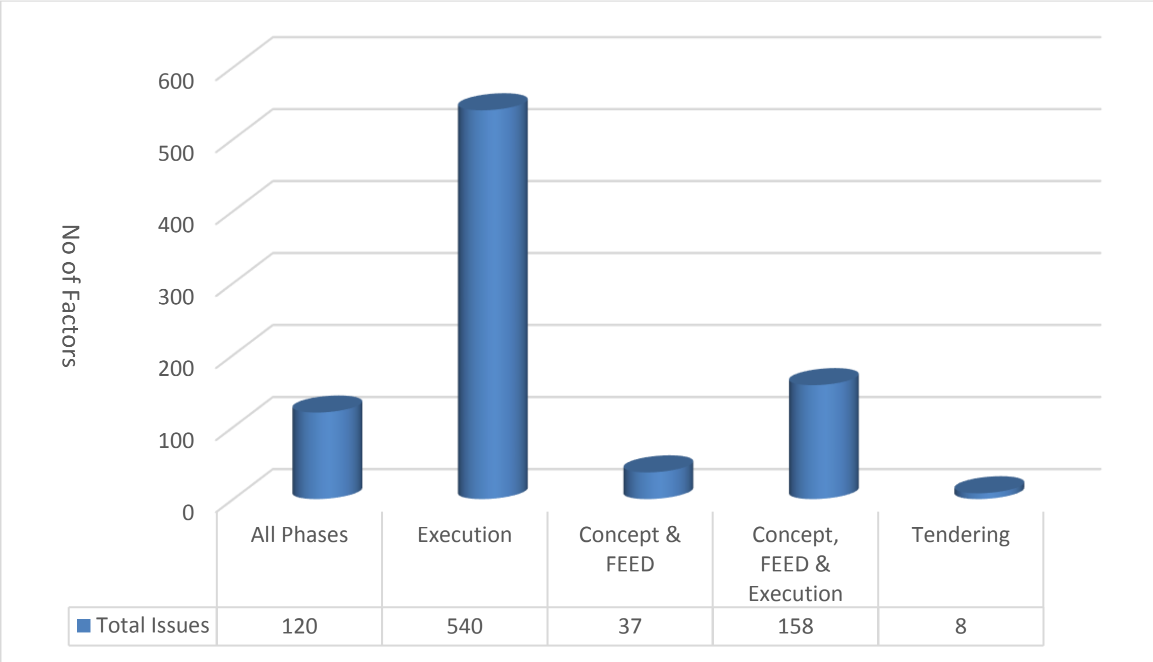


Figure (4.8) Factors based on the occurrence time – All Projects

The same result was concluded once Oil & Gas combined with general construction. It was noticed from the occurrence time that tendering had the least occurrence of factors.

Lastly, the factors which have occurred during the construction and design were examined to identify whether they can be resolved at the early phase (Concept/FEED) or if they should be addressed and resolved during related phases. It was found that there were delay factors that had occurred and were repeated in various phases of the project i.e. Concept/FEED, tendering and construction. These could be tackled and resolved at an early design phase (FEED) once they were bought forward and addressed in a timely fashion with the concerned stakeholders. Two figures have also been presented: Oil & Gas, and construction projects. They were further analysed to present resolvable factors under the individual discipline. Although certain factors occur during the construction phase, these could be prevented if there were addressed during the design phase.

The collected and categorized data was standardized using common terminology. This enabled a reduction of repetition and enables the comparison of delay factors listed by different authors in their literature.

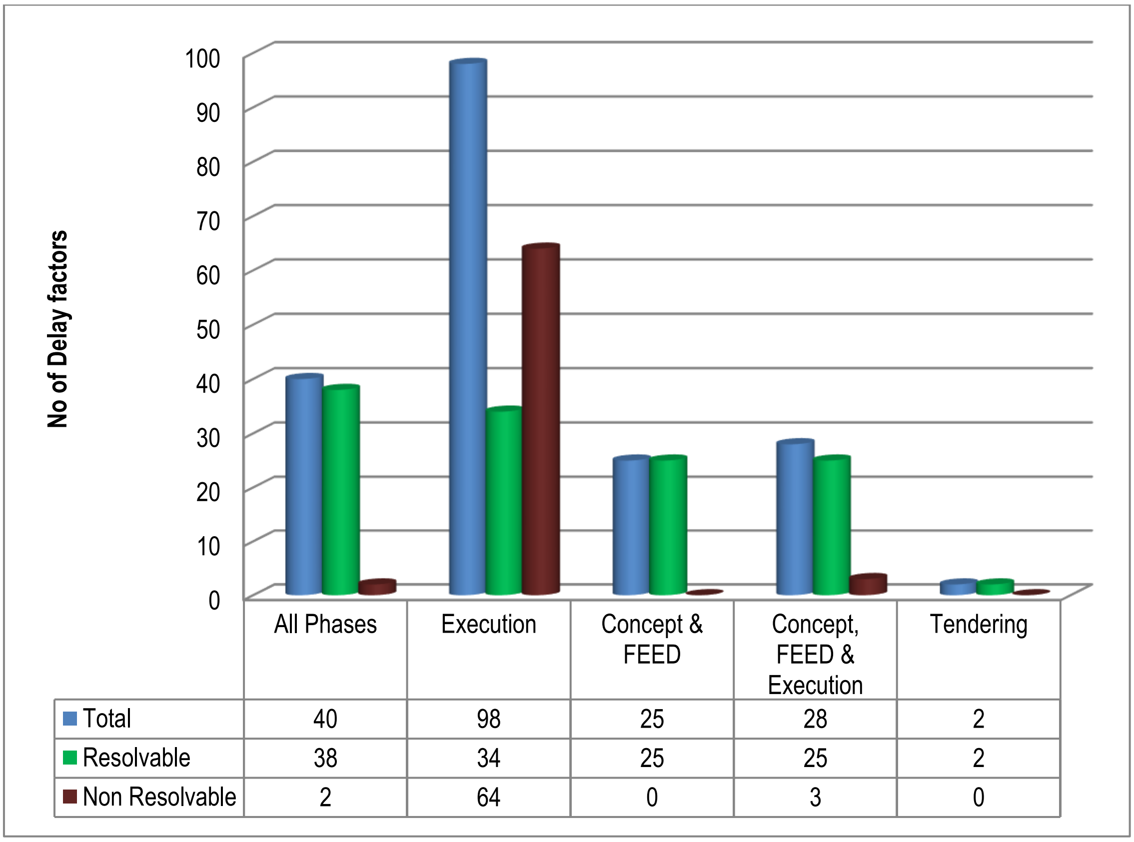
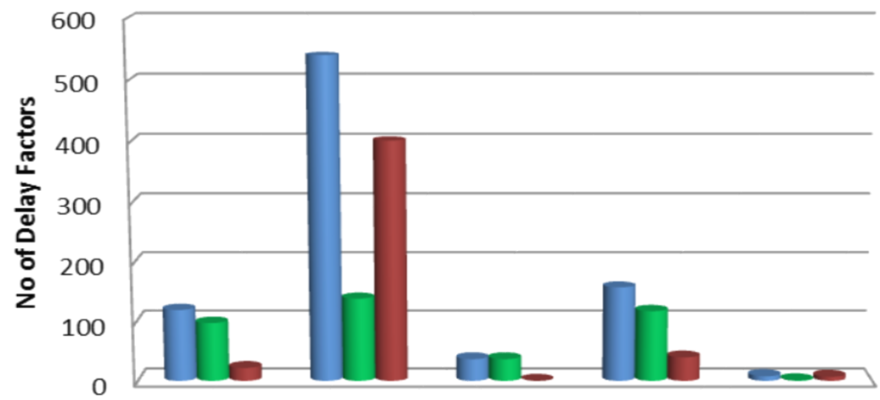


Figure (4.9) Delay Factors Resolvable Based on the Occurrence Phase – Oil & Gas

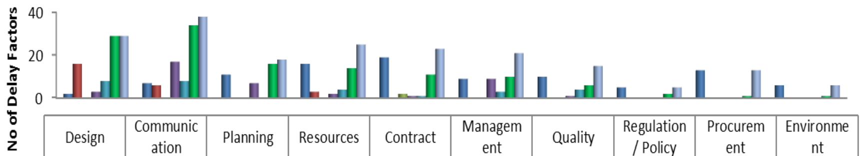
From this graph, out of 98 factors gathered from the Oil & Gas literature that occur during the construction phase, 34 can be resolved. Out of 40 factors that occurred during design, 38 can be resolved, i.e. almost all of them.



	All Phases	Execution	Concept & FEED	Concept, FEED & Execution	Tendering
Total Issues	120	540	37	158	8
Resolvable	98	139	37	118	1
Non Resolvable	22	401	0	40	7

Figure (4.10) Factors Resolvable Based on the Occurrence Phase – Construction Projects

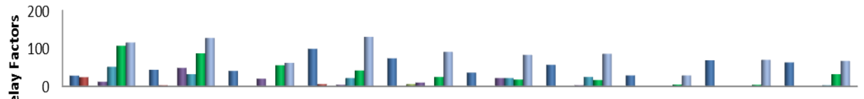
The same was plotted for the construction projects, where it was found that out of 540 factors, 139 could be resolved. The design phase showed similar results: out of 120 factors, 98 are resolvable.



	Design	Communication	Planning	Resources	Contract	Management	Quality	Regulation / Policy	Procurement	Environment
Execution	2	7	11	16	19	9	10	5	13	6
Concept & FEED	16	6		3						
Tendering					2					
All Phases	3	17	7	2	1	9	1			
Concept, FEED & Execution	8	8		4	1	3	4			
Issues Resolvable	29	34	16	14	11	10	6	2	1	1
Grand Total	29	38	18	25	23	21	15	5	13	6

Figure (4.11) Delay Factors which can be resolved during design phase – O&G, Power Plant, Utility & Pipeline Projects

This graph shows the resolvable factors if they are addressed during the design phase and the majorities are related to design, planning management and communication. These are gathered from the Oil & Gas papers.



	Design	Communic ation	Planning	Resources	Contract	Managem ent	Quality	Regulation / Policy	Procurem ent	Environme nt
Execution	28	44	41	99	74	36	57	29	69	63
Concept & FEED	24	3		6		1	1		1	1
Tendering					6	2				
All Phases	12	49	20	4	10	22	3			
Concept, FEED & Execution	52	32	1	22	1	22	25			3
Issues Resolvable	107	87	56	42	25	18	17	5	4	32
Grand Total	116	128	62	131	91	83	86	29	70	67

Figure (4.12) Category-wise Factors which can be resolved during design phase – Construction Projects

The same was verified from the construction project and the analogous result was found.

4.2.6 Factors Description

The poor performance factors below represent the selected resolvable factors identified from the literature relating to Oil & Gas, utility & power and pipeline projects. The majority of the factors related to design and communication and planning were common and repeated in different phases during the project.

Poor performance factors categorized related to Oil & Gas projects	
Lack of effective management	Improper bidding and award
Lack of Communication between engineers/Stakeholders	Client participation
Improper planning	Finance issues
Inadequate or improper planning	Inappropriate practices/procedures
Inadequate project scope definition	Owner Interference
Slow decision-making & lack of staff involvement	Design complexity
Design variations or changes in client requirement	Project managers have not full authority
Inadequate design team experience	Incomplete or inaccurate cost estimate

Poor performance factors categorized related to Oil & Gas projects	
Change orders	inadequate contractor experience
Poor estimation of labour productivity	Inconsistence of technical specifications
Mistakes and discrepancies in design	Mega size projects
Lack of mechanism for recording, analysing, and transferring project lessons learned	Inadequate control procedures
Issues regarding permissions/approvals from other Stakeholders	Non-adherence of material specifications – provided by client – to drawings
Poor documentation	Insufficient design information
Conflicts/disputes	PM characteristics
Incomplete drawings/ specifications/documents	Social and cultural factor
Delays in producing design documents	Improper contract
Wrong choice of contract type	Delay in procurement
Unforeseen ground conditions or Insufficient Site data	Delay in tendering & award
Regulations, policies & local law changes or issues	Engineering clear roles and goals
Insufficient & inexperienced management personnel from owner	Improper documentation of project objectives
Delay in site mobilization	Excessive bureaucracy in owner's organisation
Shortage of experienced and qualified engineers	Lack of IT use in communication and information management
Inadequate experience of project team	Delay in approval during construction
Insufficient team building	Inappropriate bidding instruction
Improper/outdated design software	Inappropriate overall organisation structure linking all project teams
Delayed design information	

Table (4.1) Categorized Delay factors which are resolvable – O&G

The same was listed for common and repeated poor performance factors relating to construction projects, as is presented below.

Poor performance delay factors category related to construction projects	
Unforeseen ground conditions or Insufficient Site data	Mistakes and discrepancies in contract document
Design variations or changes in client requirement	Disagreements or modifications on specifications
Lack of Communication between engineers/stakeholders	Obsolete technology
Improper planning	Inadequate experience of project team
Inadequate or improper planning	Inadequate control procedures
Slow decision-making & lack of staff involvement	Shortage of materials, poor quality & material non-availability
Mistakes and discrepancies in design	Finance issues
Delayed approval of design documents	Social and cultural factors
Lack of effective management	Materials changes in types and specifications during construction
Change orders	Lack of effective managing and controlling subcontractors
Conflicts/disputes	Rework
inadequate contractor experience	Unavailability of financial incentive for contractor to finish ahead of schedule
Incomplete or inaccurate cost estimate	Consultant recruitment delay
Poor quality assurance/control	Inappropriate project delivery system
Inappropriate overall organisation structure linking all project teams	Insufficient team building
Inadequate design team experience	Incomplete approval of design documents
Lack of consultant’s experience	Inadequate project scope definition
Design changes	Improper/outdated design software

Poor performance delay factors category related to construction projects	
Excessive bureaucracy in owner's organisation	Suspension/termination of work
Waiting for information	Inaccuracy of materials estimate
Delayed design information	Improper contract
Owner interference	Over design
Incomplete drawings/ specifications/documents	Issues regarding permissions/ approvals from other stakeholders
Design complexity	Delay in procurement
Shortage of experienced and qualified engineers	Improper technical study by the contractor during the bidding stage
Poor estimation of labour productivity	Poor competency of subcontractor
Improper bidding and award	High performance or quality expectations
Delay in approval during construction	Poor documentation
Poor site management & supervision	Unrealistic client initial requirement
Inadequate progress review	Inconsistence of technical specifications
Regulations, policies & local law changes or issues	Time extensions
Wrong choice of contract type	Poor qualification of consultant engineer's staff assigned to the project
Delay in site mobilization	Improper construction milestone definition
Conflicts of the drawing and specification	Increase in quantities
Insufficient design information	Delay in approval of major changes
Shortage of labour, skills shortage & poor productivity	Contract modifications
Regulatory changes	Lack of integration of skills at early stage of planning & design
Delays in producing design documents	Joint ownership of project
Improper codes used for design	

Table (4.2) Categorized factors which are resolvable – Construction Projects

4.2.7 Data Analysis Summary

After the literature review and data analysis were completed, it was possible to conclude with the following findings:

1. There was similarity between Oil & Gas factors and construction sectors; both sectors struggled with the same factors which led to poor performance.
2. Owner plays major role in integrating the stakeholders. A poor owner of a project team influences the entire design consultant team and a strong owner of a management team leads to good designing results.
3. All authors concluded that the majority of the delays were caused by a lack of early communication between the required stakeholders and the disconnect between the stakeholder is a reason of poor performance, which ended up with change orders and schedule & cost impacts; this is due to the gap and sequential phases.
4. Insufficient and unclear engineering design was one of the major factors behind poor performance highlighted in all the literature. The quality of the design plays a major role in the post activities and construction result. This also indicates the weak role of the design team (FEED) which led to late commencement of activities – a late start to the engineering procurement. The FEED consultant did not communicate early enough and integrate with the owners, team or designers to evaluate the feasibilities of the executions or the critical activities to enable the contractor to start. All of this led to change orders and difficulties in implementation.
5. Late delivery of materials was due to a lack of communication between the owner and contractor to approve the purchase orders. This was furthered by a communication gap between the contractor and the manufacturers leading to delays in delivery and schedule impact.
6. Other major delays were: commencing construction without all the engineering completed, land expropriation, inadequate documentation, failure to implement standards, cultural issues, poor cost estimates, insufficient data gathering & delay in mobilization, material delays, poor management, a lack of technical experience, change orders, coordination issues, poor planning, inappropriate

contractor selection and client interference. All of these were due to a severe lack of communication and integration between client, design consultant and

7. construction contractor. There are also client-related issues such as: design changes, delay in progress payments, poor owner participation. Also there are contract issues, such as: quality issues, man-power issues, natural calamities/weather conditions, inappropriate project delivery systems, difficulty in obtaining permits, delay in approvals, financial problems, inappropriate design/design errors and inappropriate duration of estimates.
8. There are factors which occur at the construction phase which can be resolved at the design phase if addressed properly.
9. Early integration at the design phase could address various poor performance factors, which have sequential effect at other factors.
10. Design consultant plays major role in the execution, by delivering a complete and high quality design. The design should reduce the construction uncertainties and clear the scope for the manufacturers.
11. Manufacturers play a major role in the claims and scope deviations, since their involvement comes very late and is inconsistent during the early phase of the design. They usually face various market conditions which require them to change design or materials due to shortage, late delivery or difficult to achieve the scope.
12. Subcontractors have the same problem, especially the main construction subcontractors; such as non-process building subcontractors, power overhead lines, earthwork, and steel subcontractors. Involving these factors at a very late stage during the construction phase encounters various site and execution problems and this leads to changes in the design or deviations.
13. Upon completion of the categorization of poor performance factors from Oil & Gas, power, utility & pipeline projects related literature, it was observed that four major categories influence project performance and other categories. These four categories are project management, design, planning and communication. It was observed that factors related to these categories are repeated in various phases of the project, i.e. the same factor occurs in the

design, then during construction; this means that the factors have a large influence on project delivery.

In the next section, the research will create and develop a framework based on the literature review considering the IPD approach and poor performance factor, this framework should address all the project execution phases; design, tendering and construction. The framework should identify and list all the stakeholders and engage them at time where collaboration and integration will resolve the poor performance factors. Factors which are related to design, planning, project management and communication will be listed in the framework based on their occurrence phase. Project execution phases will also be mentioned in the initial framework.

4.3 Initial Framework Development

An initial framework will be created to address the method of integrating project stakeholders and how the IPD approach will be conceptualized. One of the objectives of the initial framework is to overcome the current factors behind poor performance and.

Design consultant develops the engineering documents with less communication with construction contractor and manufacturers and without update to the market, i.e. regulation changes, resources availability, technology changes, materials availability, deliverability and schedule, due to time limitation during the design, or design consultant engineers relies on the previous knowledge and experience and is not up to date with the market changes. Construction contractor and manufacturers' involvements and inputs will be captured and included during the design phase to cater for any technical and commercial impact and to obtain the appropriate approvals. Nevertheless, by integrating the manufacturers during the design means that all the manufacturers' clarifications, options and deviations can be answered prior to any commercial commitment. The above should positively contribute towards better commercial bidding and realistic scheduling since contractors along with manufacturers will be more likely to have the same technical understanding before the construction contract bidding. The same has to be extended to subcontractors, specialized consultants and other stakeholders including the government authorities. In many projects, government bodies have various requirements and guidelines on the ground which are frequently updated and improved, where consultant and owner do not cater their guidelines and procedures, such as in the design phase concerning issues like transportation, work permits, labour laws, lands releases, power connections, etc. Similar issues with operation and maintenance late involvements, if the owner end users are involved during the design, all the operation and maintenance lessons learnt and concerns should be captured in the design and all the drawings and dimensions will be incorporated in the design. This will assist in commission the facilities, operate and maintain them will less risk and improve the productivity by the end users. In addition, this will help the end users to identify and exclude any poor support by manufacturers.

4.3.1 Creating a framework based on IPD Principle

The proposed initial framework will ensure that all of the essential stakeholders are involved during the design phase and each possible factor should be tackled with a solution by integrating them at the required time and event during each phase, mainly during the concept, FEED design phase (early phases), before any contractual obligation restricts the possible mitigation measures to overcome the problems which may arise during construction. The same approach can be extended during the concept phase to bring the owner with other required stakeholders. As examples, the concept design consultant and the owner will be collaborating along with the end user at a very early stage such as the design concept phase, where the owner will ensure the project ultimate objectives are clearly communicated and documented and the concept design consultant will ensure these objectives are captured, defined and requirements are well developed. In addition, the end users (operating and maintenance stakeholder) will be involved and integrated with the team at the concept stage to ensure all their concerns are captured.

The initial framework will look at each possible poor performance factor which could be resolved within the identified timeframe and with the involvement of related stakeholders. Based on data sampling, the factors related to design, management, planning and communication have been thoroughly analysed since most authors have listed the factors under these three categories as the highest rated factors causing delays in projects. Although other categories poor performance factors may also be addressed and resolved using the same approach, the researcher has focused on the most schedule-, quality- and cost-influencing factors. Other unlisted factors and groups may get reflected based on the project nature and conditions. The resolvable factors under design, management communication and planning have been drafted based on the literature feedback and list. The same factors will be examined under case studies and validated individually, Revision (1) literature reference factors extracted and listed in Table and the same is represented in the below framework.

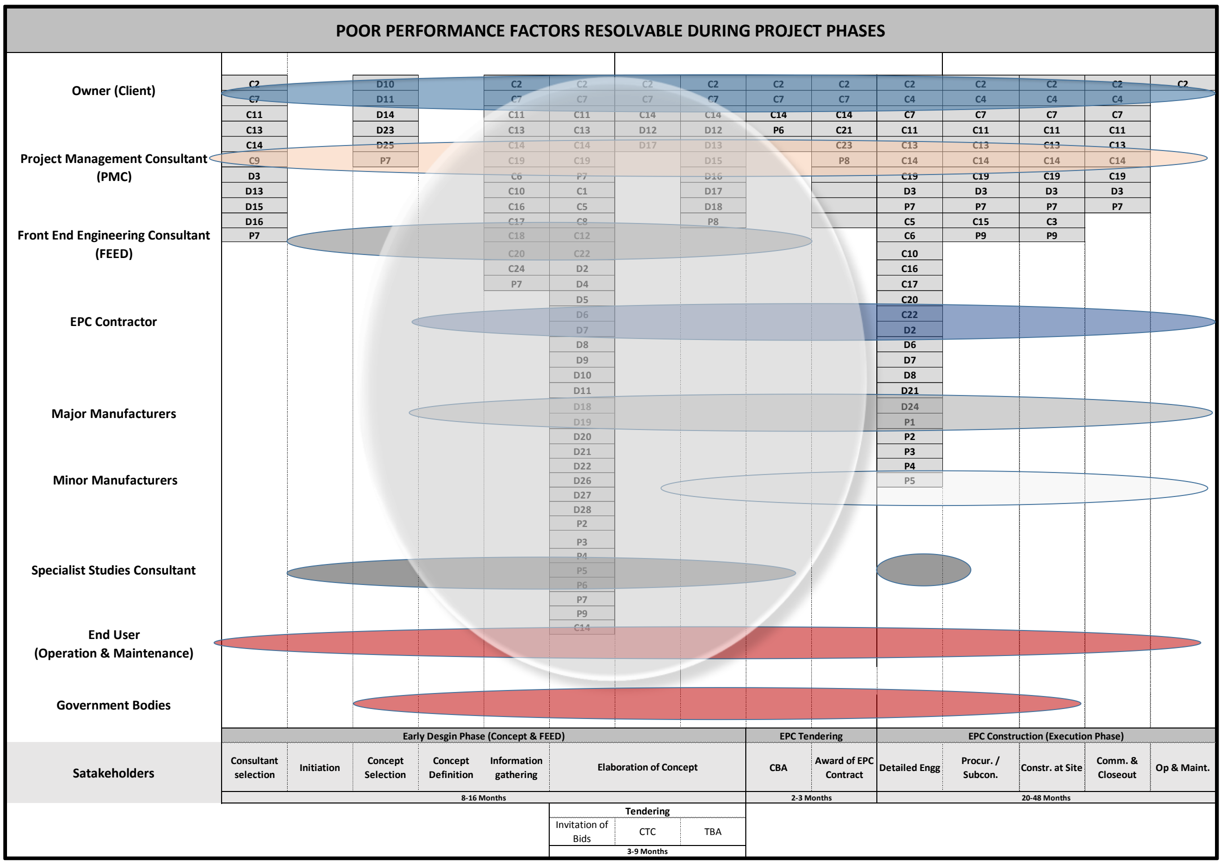


Figure (4.13) Initial Conceptual Framework

The initial framework was plotted with a matrix structure where all the key stakeholders are listed in the lift column, such as; the owner, project management consultant (PMC), FEED designer, EPC contractor, major manufacturers/minor manufacturers, specialized study consultants, end users (operation and maintenance) and government bodies. On the bottom row, the project phases have been plotted starting from early design phases (Concept and FEED), which have several milestones to complete, such as, consultancy selection and qualifying them for the scope to concept initialisation, moves to concept selections if more than one proposal is presented and design execution. Once the design is complete, the owner moves to the execution bidding/tendering phase, where the owner invites all of the qualified contractors to bid for the scope; this duration varies from project to project based on the locations, complexity and other factors. A step later, once the bidding is completed, the execution phase begins by awarding the contract, starting the detailed engineering, procurement, construction and followed by commissioning and operation. The matrix plots the factors related to design, management, planning and communication as per their occurrence phase, i.e. factors which have occurred during the design will be plotted under the design phase, factors occurred under the tendering or execution will be plotted under the execution and tendering phases, repeated factors or those occurred under more than one phase also will be plotted as per their occurrence frequency. The factor codes are detailed in the below table. The framework demonstrates each stakeholder participation and integration phase, i.e. the owner is required to participate during the entire project life cycle, and the project management consultant is required to participate during the entire project cycle. By this involvement, all of the covered factors should be resolved and tackled by both owner and project management consultant and they should aim to resolve these factors. Resolving the repeated factors will result in addressing these factors early and avoiding repeating them in the next phase of the project. It is the same with other stakeholders, i.e. involving them as early as in the design will allow them to resolve the factors related to their fields and concerns. From the circle shape, it is expected that during the design phase (concept and FEED), the majority of the factors will be addressed and resolved including the factors which occur at the construction and execution phase since the late integrated stakeholder will be participating during the design and should bring forward all their concerns which the design ignore or miss. For example, once the government bodies will be aware of the project during the design, all of the government guidelines and procedures will be captured and covered to protect the execution phase and eliminate and late changes in the design or in the ground. This involvement will more detail the construction scope of work and the interfacing section the scope to address all the concerns and coordination and communication procedures. This initial framework will be validated by case studies and could be adjusted to fit the solution and execution by the case studies participants.

4.3.2 Factors related to communication Design, Project Management and Planning

The table below lists the factors with their code in the framework, and divides them into three groups: communication, design and planning. The management factors or group was imbedded in the three groups above since they are mentioned under each, therefore they were not presented as a code in the framework or in the below table.

Code	Finding (All Project Types)	Code	Finding (All Project Types)
Communication			
C1	Client participation	**C13**	Joint ownership of project
C2	Conflicts/disputes	**C14**	Lack of communication between engineers/Stakeholders
C3	Delay in approval during construction	**C15**	Lack of effective managing and controlling subcontractors
C4	Delay in approval of major changes	**C16**	Lack of integration of skills at early stage of planning & design
C5	Delayed approval of design documents	**C17**	Lack of IT use in communication and information management
C6	Delayed design information	**C18**	Lack of mechanism for recording, analysing, and transferring project lessons learned
C7	Excessive bureaucracy in owner's organisation	**C19**	Owner interference
C8	Improper documentation of project objectives	**C20**	Poor documentation
C9	Inadequate design team experience	**C21**	Poor site management & supervision
C10	Inappropriate overall organisation structure linking all project teams	**C22**	Slow decision-making & Lack of staff involvement
C11	Insufficient team building	**C23**	Social and cultural factor
C12	Issues regarding permissions/ approvals from other Stakeholders	**C24**	Unforeseen ground conditions or Insufficient Site data
Design			
D1	Delay in preparation of shop drawings	**D15**	Improper technical study by the

Code	Finding (All Project Types)	Code	Finding (All Project Types)
	and material samples		contractor during the bidding stage
D2	Change orders	**D16**	Inadequate design team experience
D3	Conflicts/disputes	**D17**	Inadequate project scope definition
D4	Conflicts of the drawing and specification	**D18**	Incomplete drawings/ specifications/documents
D5	Delayed approval of design documents	**D19**	Inconsistence of technical specifications
D6	Delayed design information	**D20**	Increase in quantities
D7	Delays in producing design documents	**D21**	Insufficient design information
D8	Design changes	**D22**	Materials changes in types and specifications during construction
D9	Design complexity	**D23**	Mega size projects
D10	Design variations or changes in client requirement	**D24**	Mistakes and discrepancies in design
D11	Disagreements or modifications on specifications	**D25**	Obsolete technology
D12	Engineering clear roles and goals	**D26**	Overdesign
D13	Improper/outdated design software	**D27**	Rework
D14	Improper codes used for design	**D28**	Unforeseen ground conditions or insufficient site data
	Planning		
P1	Improper construction milestone definition	**P6**	Incomplete or inaccurate cost estimate
P2	Improper planning	**P7**	Lack of effective management
P3	Inaccuracy of materials estimate	**P8**	Poor estimation of labour productivity
P4	Inadequate or improper planning	**P9**	Time extensions;
P5	Inappropriate overall organisation structure linking all project teams		

Table (4.3) Resolvable Factors – All Projects – Communication, Design & Planning

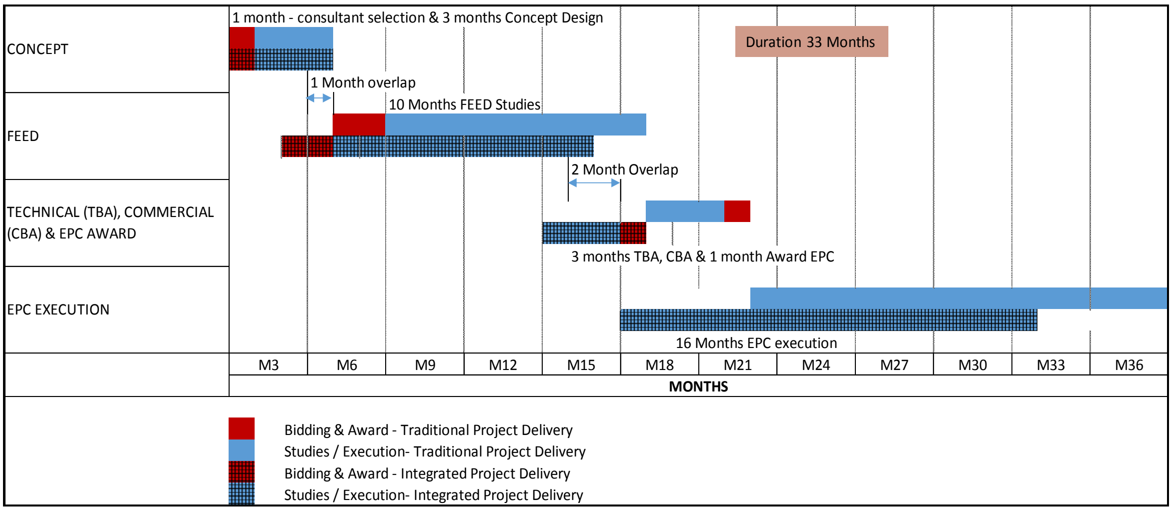


Figure (4.14) Typical IPD project execution schedule including all phases and stages

The above schedule represents the sequence of phase with its average duration. The duration is varying based on the project size from 33 to 60 months. As for design, it varies from eight months to 15–20 months based on various factors.

The above schedule shows that the phases are sequential and move from phase to phase, and usually there is a clear gap between the designer and the execution contractor due to the bidding phase.

The framework emphasises that with stakeholder's integration and involvement during the design, more precise work can be done in the design detailing and with a reduction in the number of assumptions, more realistic schedules can be developed.

One key point is that the schedule will be reduced since key stakeholders will come very early in the project and their knowledge and experience will enrich the design at an early stage. This will allow their project members to understand the project early, clarify the scope early and issue their quotations for pricing to all manufacturers and sub-contractors early too. All of this should contribute to reducing the schedule of bidding and the technical and commercial clarification duration. From the below schedule, the duration and phases will be bridged to reflect this integration. This integration will also ensure the owner take advance stop to invite the interested bidders to participate in the project since their involvement is required during the design.

On the other technical point view, Building Information Model (BIM) such as 30%, 60% and 90% 3D design model can be developed with good detailed information. In addition to the above, the tendering phase will get shortened since the same will be done during early design. The time float generally estimated for the execution phase is lower, since design is done with all procurement & constructability related information from stakeholders, thereby the number of changes/variation in design or changes in stakeholder expectations is fewer.

4.3.3 Piloting the Questions

The initial case study questions have been developed based on the collected data and initial framework proposal. To ensure high quality case study contents and improve the quality of the case study questions, it was decided to examine the interview questions by interviewing three to five Oil & Gas project experts as a pilot run and to obtain their feedback and comments, then accordingly finalise the case studies' interview questions.

The structure and sequence of each piloting interview was developed as follows:

1. Provide Introduction to the interviewees on the research objective and background;
2. Present the initial framework at the beginning;
3. Assist the interviewees to answer the questions (Section-1);
4. Assist the interviewees to answer open questions (Section-2);
5. Open discussion on the initial framework implementation;

The piloted questions were bisected into three sections;

1. Common delay factors
2. Objective questions
3. Subjective question

Sr. No	Description (Revision 3)
Section A: Common poor performance factors	
1	Lack of effective project management. Inadequate experience of project team from all parties
2	Insufficient team building during design and EPC
3	Inappropriate overall organisation structure linking all project teams
4	Conflicts/disputes between stakeholders (owner, project team and operations)
5	Project manager does not have full authority
6	Insufficient & inexperienced management personnel from owner
7	Frequent owner interference
8	Excessive bureaucracy in owner's organisation
9	Issues regarding permissions/approvals from other stakeholders
10	Slow decision-making and lack of staff involvement from owner side
11	Lack of IT use in communication and information management
12	Lack of mechanism for recording, analysing, and transferring project lessons learned.
13	Inadequate control procedures from owner side to monitor the progress and delay
14	Incomplete or inaccurate cost estimate by owner & EPC Contractors
15	Inadequate or improper planning/schedule from Owner to deliver the project
16	Poor estimation of labour productivity by EPC
17	Delay in preparation and approval of documents by owner and FEED consultant/contractor
18	Lack of client participation in major milestones during design
19	Mega size, design complexity and complications
20	Design variations or changes in client requirement
21	Inadequate project objective and scope definition by owner and FEED designer
22	Lack of engineering clear roles/goals
23	Poor quality of deliverables by FEED designer
24	Delayed or insufficient design information from owner
25	Lack of communication between FEED engineers and other stakeholders (operation & maintenance)
26	Inconsistency between specification, prevailing international standards and owner's procedures/specifications
27	Outdated design software
28	Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding
29	Delay in tendering and award schedule
30	Inadequate contractor experience - all phases, unfamiliar with regulations, policies & local law changes or issues and lack of knowledge in social & cultural factors
31	Delay in procurement by contractor
32	Financial issues of contractor during execution

Sr. No	Description (Revision 3)
33	Delay in mobilization during design & EPC
34	Flexibility of client to adopt technical changes
35	Less time for EPC tendering & too many bidders
36	Limited capability of local contractor
37	Limited authority of PMC consultant
38	Poor technical decision by PMC during tendering
Section B: General Objective questions	
1	Did the interviewer work in different countries: where?
2	Did the interviewer work in other than Oil & Gas projects? What type?
3	Whether the collected factors related to a specific Region/ country or globe
4	Whether the collected factors specific to all Oil & Gas projects or they are applicable to all construction industry?
5	Can the selected factor can be resolved as per the initial frame work or not?
6	Does the proposed framework have any cost impact on owners
7	Are you aware of Integrated Project Delivery (IPD) model or a similar model?
8	Do you believe that the project delivery method has an impact on the project performance?
9	How comfortable will you be to work in a project which is being executed on the lines of a IPD
Section C: General Subjective questions	
1	What scale of Oil & Gas projects are more prone to delays and cost overrun?
2	Have you encountered any delay factor which has not been addressed in the questions above? And who are the stake holders responsible for their occurrence & resolution?
3	In addition to the stakeholders identified in Section A, do you identify any other stakeholder who can be a reason for causing a delay or who can resolve a delay factor?
4	Can you explain the project execution strategies you have worked in the past projects and which one has been more widely used in the organisation/projects you have worked for?
5	What percent of the delay factors encountered in the project are resolvable early in the project? Do you foresee any delay factor not resolvable during early phase but which occurs very often in Oil & gas projects?
6	Do you see any advantage of IPD for executing Oil & gas projects?
7	What can be the possible disadvantages of adopting IPD depending on the scale of the project being executed

Table (4.4) Case Study (Interview) Questions

Piloting duration, interaction and discussion were recorded in order to improve the interviews durations and ask the piloting expert about his/their own feedback and preference on the quality and questions numbers and sequences.

The case studies questions were piloted before moving for first case study; this was important to examine the quality of questions and provide and make any necessary improvements. The pilot run was carried out in two stages; the first stage was conducted with three expert participants without any suggested changes in the format and the interview question, in order to gather different feedback and comments, then with one expert. However, the same feedback was shared with the other expert to provide a proper weightage for the comments. After the three expert separate interviews were finished, the researcher amended the questions based on the first pilot feedback and improvement suggestions. It was noted during the pilot interviews that the interviewees felt some of the questions had the same or similar meaning and could be combined to reduce repetition and time. Initially this was noticed and requested from the first expert interviewee, and then the same was requested by the second and third pilot interviewees to combine or delete the repeated/similar meaning questions which have same answers. Based on this feedback, questions of a similar nature were combined and reworded.

It was necessarily for the researcher to test the quality of questions again (second stage) before carrying on further and get fourth and fifth inputs for improvement. All first stage pilot interviewees have provided their valuable inputs and their observations were recorded and implemented in Revision 2 of the questions. Both revisions were presented to the fourth and fifth pilot interviewees to examine and confirm the previously received feedback by the three interviewees. Again the researcher looked into repeated meaning questions with the same answers during the fourth and fifth interviews were carried. Based on this exercise, the number of questions which can be merged were identified and modified accordingly. It was very important to study the way to merge the questions in order to avoid any mismatch between the secondary data (literature delay factors) and primary data from the interviews. In addition to the above similarity in meaning, it was observed that the interview duration was between two to three hours, which was quite long with very limited given time from the interviewees, therefore merging was also shortening the duration and kept the interviewees focused and interested to complete the questions.

To perform the merging carefully, the researcher firstly tabulated the secondary data, which was collected from the literature (poor performance factors) and which was used for the first three interviews (see the below Revision.1 column) and compiled the factors again; however, each factor was again inserted opposite the Revision 1 column in order to compare whether the factor from Revision 1 was merged or kept as is in the next revision. Factors which are combined were written in the second column with the merged Revision 1 factors, i.e. it was suggested to merge revision 1 delay factors 1, 6, & 15 under one delay factor in Revision 2 column. Factor number 2 in Revision 1 was kept as it is in Revision 2, since it could not be merged with any other delay factor. To quote another example, questions number 16, 23, 24, 25 and 46 from revision 1 were also merged under one delay factor in Revision 2. The same was repeated till all the delay factors under Revision 1 were qualified for merging if required. The below table illustrates all the secondary data of Revision 1 before and after merging (column number 2). The responses from the three initial participants have been checked for consistency for the questions merged. The same logic shall be applied during the analysis of the responses.

Sr. No	**Description (Revision 1)**	**Sr. No (rev. 2)**	**Description (Revision 2)**
1	Lack of effective project management.	1, 6 & 15	Lack of effective project management. inadequate experience of project team from all parties
6	Inadequate experience of project team		
15	Inadequate design team experience from all stakeholders		
2	Insufficient & inexperienced management personnel from owner.	2	Insufficient & inexperienced management personnel from owner.
3	Inappropriate overall organisation structure linking all project teams.	3	Inappropriate overall organisation structure linking all project teams.
4	Frequent owner interference.	4	Frequent owner interference.

Sr. No	Description (Revision 1)	Sr. No (rev. 2)	Description (Revision 2)
5	Excessive bureaucracy in owner's organisation.	5	Excessive Bureaucracy in owner's organisation.
7	Project Manager does not have full authority.	7	Project Manager does not have full authority.
8	Lack of communication between FEED engineers and other stakeholders (Operation & maintenance)	8	Lack of communication between FEED engineers and other stakeholders (Operation & maintenance)
9	Slow decision-making & lack of staff involvement from Owner side.	9	Slow decision-making & Lack of staff involvement from Owner side.
10	Inadequate or improper planning/schedule from owner to deliver the project	10	Inadequate or improper planning/schedule from owner to deliver the project
11& 42	Delay in site mobilization	11	Delay in mobilization during design & EPC
12	Inadequate control procedures	12	Inadequate control procedures from owner side to monitor the progress and delay.
13	Incomplete or inaccurate cost estimate	13	Incomplete or inaccurate cost estimate by owner & EPC contractors.
14	Inadequate/unclear project scope definition	14 & 30	Inadequate project objective and scope definition by owner and FEED designer.
30	Improper documentation of project objectives		
18	Lack of Client participation in major milestones during design	18	Lack of Client participation in major milestones during design
19	Lack of engineering clear roles/goals	19	Lack of engineering clear roles/goals
20	Poor documentation by designer	20	Poor quality of deliverables by FEED designer
21	Design complexity	21 & 45	Mega size, design complexity and complications.
45	Mega size projects		

Sr. No	Description (Revision 1)	Sr. No (rev. 2)	Description (Revision 2)
16	Mistakes and discrepancies in design from the designer (FEED)	16, 23, 24, 25 & 46	Inconsistency between specification, prevailing international standards and owner's procedures/Specifications
23	Inappropriate practices/procedures by owner		
24	Incomplete drawings/specifications/documents by designer		
25	Inconsistence of technical specifications		
46	Non-adherence of material specification provided by client while preparing drawings		
22	Improper/outdated design software by owner	22	Outdated design software
28	Design variations or changes in client requirement	28	Design variations or changes in client requirement
29	Poor estimation of labour productivity (engineering & construction)	29	Poor estimation of labour productivity by EPC
31	Lack of mechanism for recording, analysing, and transferring project lessons learned.	31	Lack of mechanism for recording, analysing, and transferring project lessons learned.
32	Delay in issuing permissions/approvals from other stakeholders	32 & 49	Issues regarding permissions/approvals from other stakeholders
49	Delay in approval during construction		
33	Delayed design information by owner	33 & 26	Delayed or insufficient design information from owner
26	Insufficient Design Information		
34	Conflicts/disputes between stakeholders	34	Conflicts/disputes between stakeholders (owner, project team and Operations)
35	Wrong choice of contract type by owners	35, 36 & 38	Wrong choice of contract type or Improper bidding and award strategy by owner and inappropriate bidding
36	Improper bidding and award strategy by owner		

Sr. No	Description (Revision 1)	Sr. No (rev. 2)	Description (Revision 2)
38	Inappropriate bidding instruction		instruction during bidding.
37	Delay in tendering and award	37	Delay in Tendering and award schedule
39	Inadequate contractor experience	39, 40 & 41	Inadequate contractor experience - All Phases, unfamiliar with Regulations, policies & local law changes or issues and lack of knowledge in social & cultural factors
40	Regulations, Policies & local law changes or similar issue		
41	Social and cultural factors		
43	Insufficient team building	43	Insufficient team building during design and EPC
44	Finance issue by contractor	44	Financial issues of contractor during execution
47	Delay in procurement by contractor	47	Delay in procurement by contractor
48	Lack of IT use in communication and information management	48	Lack of IT use in communication and information management
27	Delay in producing design documents	27	Delay in Producing design documents

Table (4.5) Case Study (Interview) Questions Rev. 1 & Rev.2

Based on Revision 2 questions, two interviews were planned and conducted to test the merged revision. The third participant affirmed that the interview based on this revision took less duration and assisted in providing more focused answers, however both third and fourth interviewees suggested revising the sequence of questioning in order to streamline the flow of the interview. This would address all poor performance factors which can be categorized under a phase or field of responsibility before moving to the next set of questions. This suggestion was in line with the delay factors which were grouped to design, communication, planning and project management. Implementing this suggestion was necessary since sorting the questions in sections will help securing better quality of response from the interviewees and will help reducing the duration of the interview further by channelizing the flow of the questions, in addition to the fact that this regrouping is aligned with the literature analysis.

It was mentioned by one of the piloting interviewees that each factor in questions from Section A of the questions can be answered if the question can be resolved during the early design phase or not, rather than asking the question under section B. Since some factors may be resolvable in early design and some may not be resolvable, this suggestion was very constructive and the researcher included a column to ask the interviewees whether each delay factor can be resolved during the design. The question under section B related to the above was deleted accordingly. The question “The delay factors presented in Section A can occur in one phase of the project or they can occur in all phases?” can be avoided in section B (General) since the same has been captured for individual delay factors in Section A. These suggestions were very relevant to the objective of the research and hence were implemented in the Revision 3 of the questions and the revision presented the final revision.

After implementation of the comments, Revision 3 has been prepared for future interviews. The same is presented in the table below, the question sequence was revised.

Sr. No (Rev. 2)	Description (Revision 2)	Sr. No (Rev. 3)
1, 6 & 15	Lack of effective project management. Inadequate experience of project team from all parties	1
43	Insufficient team building during design and EPC	2
3	Inappropriate overall organisation structure linking all project teams	3
34	Conflicts/disputes between stakeholders (owner, project team and operations)	4
7	Project manager does not have full authority	5
2	Insufficient & inexperienced management personnel from owner.	6
4	Frequent owner interference.	7

Sr. No (Rev. 2)	Description (Revision 2)	Sr. No (Rev. 3)
5	Excessive bureaucracy in owner's organisation.	8
32 & 49	Issues regarding permissions/approvals from other stakeholders	9
9	Slow decision-making & lack of staff involvement from owner side.	10
48 & 27	Lack of IT use in communication and information management	11
31	Lack of mechanism for recording, analysing, and transferring project lessons learned.	12
12	Inadequate control procedures from owner side to monitor the progress and delay.	13
13	Incomplete or inaccurate cost estimate by owner & EPC contractors.	14
10	Inadequate or improper planning/schedule from owner to deliver the project	15
29	Poor estimation of labour productivity by EPC	16
17	Delay in preparation and approval of documents by owner and FEED consultant/contractor	17
18	Lack of client participation in major milestones during design	18
21 & 45	Mega size, design complexity and complications.	19
28	Design variations or changes in client requirement	20
14 & 30	Inadequate project objective and scope definition by owner and FEED designer.	21
19	Lack of engineering clear roles/goals	22
20	Poor quality of deliverables by FEED Designer	23
33 & 26	Delayed or insufficient design information from owner	24
8	Lack of communication between FEED engineers and other Stakeholders (Operation & maintenance)	25
16, 23, 24, 25 & 46	Inconsistency between specification, prevailing international standards and owner's procedures/specifications	26
22	Outdated design software	27

Sr. No (Rev. 2)	Description (Revision 2)	Sr. No (Rev. 3)
35, 36 & 38	Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding	28
37	Delay in tendering and award schedule	29
39, 40 & 41	Inadequate contractor experience - all phases, unfamiliar with regulations, policies & local law changes or issues and Lack of knowledge in social &cultural factors.	30
47	Delay in procurement by contractor	31
44	Financial issues of contractor during execution	32
11	Delay in mobilization during design & EPC	33

Table (4.6) Case Study (Interview) Questions Rev. 2 & Rev.3

Based on the above changes, the questions were modified and reformatted to represent Revision (3). It was also necessary to add two more questions in order to validate whether the delays related to specific region or global, therefore a question was added: “Did the interviewee work in different countries: where?”. The second question added was, “Did the interviewee worked in projects other than Oil & Gas projects? What type?” – this question was important to understand and validate the relation and relevance of the delay factors collected in secondary data with all construction type projects including Oil & Gas projects. Below questions were added to the list based on the several requests from the piloting experts to improve the variety and cover all the topics, these questions were as follow:

1. Flexibility of client to adopt technical changes
2. Less time for EPC tendering & too many bidders
3. Limited capability of contractor
4. Limited authority of PMC consultant
5. Poor technical decision during tendering by PMC

Finally, the questions were grouped and reshuffled to represent four sections or factors similar to the literature poor performance factors; i.e. the sequence and grouping was done to represent project management factors questions, then planning and project control, technical questions, this regrouping also helped to perform the analysis at later stage and compare it with the literatures analysis and findings. The objectives and value of the piloting was noticed loudly with all the interviewees and quality of time and answers were also observed during the first case study responses.

In the next chapter (6), the researcher will validate the developed initial framework by case studies. The case study structure and interviews approach with the data analysis from the interviews' outcome will be mentioned in the next chapter.

Chapter 5. CASE STUDIES

5.1 Introduction

Although all of the case studies will be selected from projects that were executed in UAE, these projects' FEED designing consultants, EPC construction contractors and manufacturers/suppliers are international (i.e. from USA, Europe, China, India, Japan and South Korea, etc.). In addition, poor performance factors are typical for all the projects around the globe and the same also was obvious in the factors which were collected from projects were executed around the globe, in addition; the approached Oil & Gas Companies in Middle East, have three to five International Oil & Gas Shareholders such as (Shell, Exon Mobile, BP and Total), therefore these case studies will serve the global Oil & Gas sector – not specifically the UAE market or Middle East.

5.2 Case Study Objective

This research adopted a case study strategy and semi-structured interviews approach. The collected poor performance factors and developed framework will be validated using a case study approach and interviews with selected projects key stakeholders to provide their views and answers to selected and pre-defined questions.

The following will be the key objectives of the case studies:

1. To validate and evaluate the collected poor performance factors from the literature.
2. To add any other genuine factors impacting project schedule and cost.
3. To validate the initial framework and develop the final framework and implementation process.

5.3 Case Study Execution Method

5.2.1. Case structure

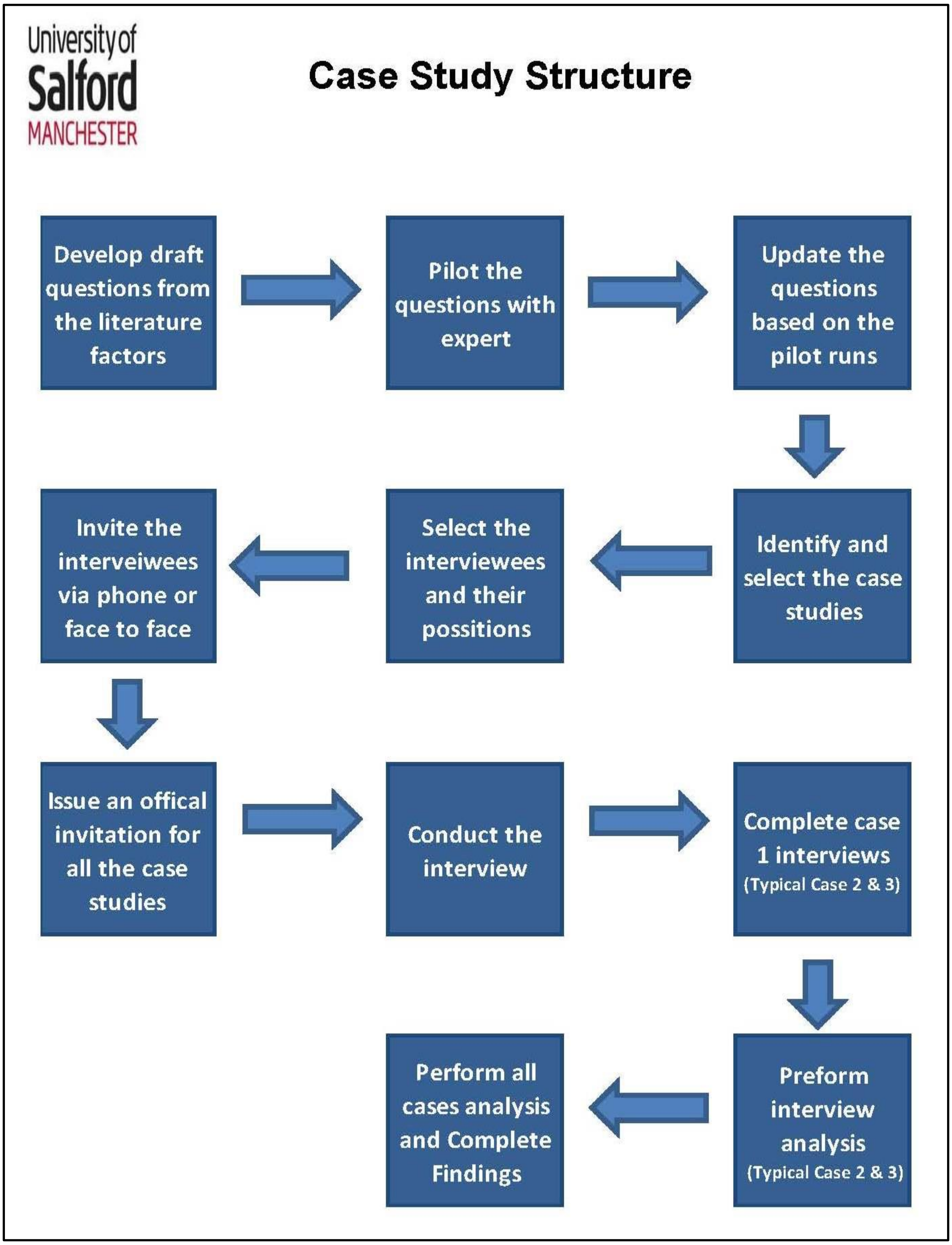


Figure (5.1) Case Study Structure

The research developed the set of questions from the literatures on performance factors and Project delivery methods. These questions were in line with the information that is required for the analysis of project delivery method and assist in effectively analysing the problems faced by projects presently. The questions were piloted with projects Subject Matter Experts for the relevance and flow. This not only helped in improving the questions but also reaffirmed the findings from literature. Four interviews were carried out with the developed questions and inputs from these interviewees were used to further improve the questions sets and sections.

In the next stage the research identified the case studies as detailed in the subsequent section. The case studies were selected from the Oil & Gas projects executed in Middle East recently. All the selected case studies had multiple stakeholders' interfaces internationally and had a complete Engineering Procurement and Construction phases as normally for major Oil & Gas Projects. Subsequent to the selection of case studies the researcher identified the ley stakeholders for each of the case studies. The intention behind identification of key stakeholders was to benefit the most from the interviews by nominating stakeholders with key roles and responsibilities and who have different perspective of the same project based on their role. The nominated Interviewees were sent invitation through phone or face to face to be a part of the research study. Key information about the interview along with confidentiality statement was issued to each of the interviewees along with an official invitation for interviews.

On acceptance of interview invitation the case study 1 was conducted with 12 interviewees. The results obtained from the case study 1 interviews were plotted in graphs for analysis. The graphs were used to segregate the interview results by factor occurrence phase, responses against individual factor and responses by individual interviewees. These graphs were further analyzed and results were objectively studied by the research. The sequence of questions and the repetitive questions were merged after first few interviews. This helped in reducing the interview duration and also maintained the flow and focus during the interview.

Subsequent to the updation of questions after first case study similar process of interviewee selection and invitation was conducted for Second case study. 14 interviews were conducted for the Second Case Study. The results from Second case study was also Plotted in graphs, analysed and results were studied by researcher.

Third case study was concluded by conducting six interviews on interviewees selected as detailed for first case study. The results from the third case study interviews was also plotted in graphs, analysed and results were studied by researcher.

Once all the case studies interviews were completed a combine analysis were conducted and case study conclusions were drawn from all three case studies and presented in subsequent section below.

5.2.2. Case Study Selection Criteria (Project Name)

The researcher will select three case studies to validate the framework; the case studies will be selected from existing Oil & Gas projects executed in the Middle East, where billions of US dollars are spent on projects every year. These projects were designed by international FEED designing consultancies and executed by international EPC contractors and all the supplies were procured from global manufacturers, in addition, the type, size, complexity and scope of these projects are typical to the Oil & Gas industry worldwide and follow the same international standards and code of practices, therefore these projects considered as typical to the entire Oil & Gas sectors and not specific to a country or region.

The researcher had on behalf of one of the international companies presented during an international conference a number of projects which were impacted negatively in schedule and cost due to various delay factors. The company had also taken the initiative to gather the main stakeholders to listen to their concerns and main problems behind the projects’ poor performance as delays and major claim cases then also conducted focus group workshop to discuss and identify the major poor performance factors, which caused schedule and cost impact for the last five major projects. The findings and results were very much typical to those been published and collected from the literatures. From various presented projects during the workshops and discussion, the researcher has identified three projects which were impacted by cost and schedule; the same could be presented for improvements and can be improved by implementing the initial framework as follows. One of these cases was a successful case were less schedule delays and claims were encountered due to various initiatives being taken by various stakeholders to have a collaborative approach.

Case Study (1): Projects had major delay factors, where schedule and cost overruns have impacted all of the stakeholders and mainly owners and EPC construction contractors.

Case Study (2): Projects had major construction claim cases by the contractor due to severe delays in schedule and work requirement changes.

Case study (3): (Traditional Strategy and Success Project): This project was executed on traditional execution strategy where the contractor and other stakeholders were successfully delivered the project with less impact on schedule. This case could be a model if the framework was used, since many factors could be resolved.

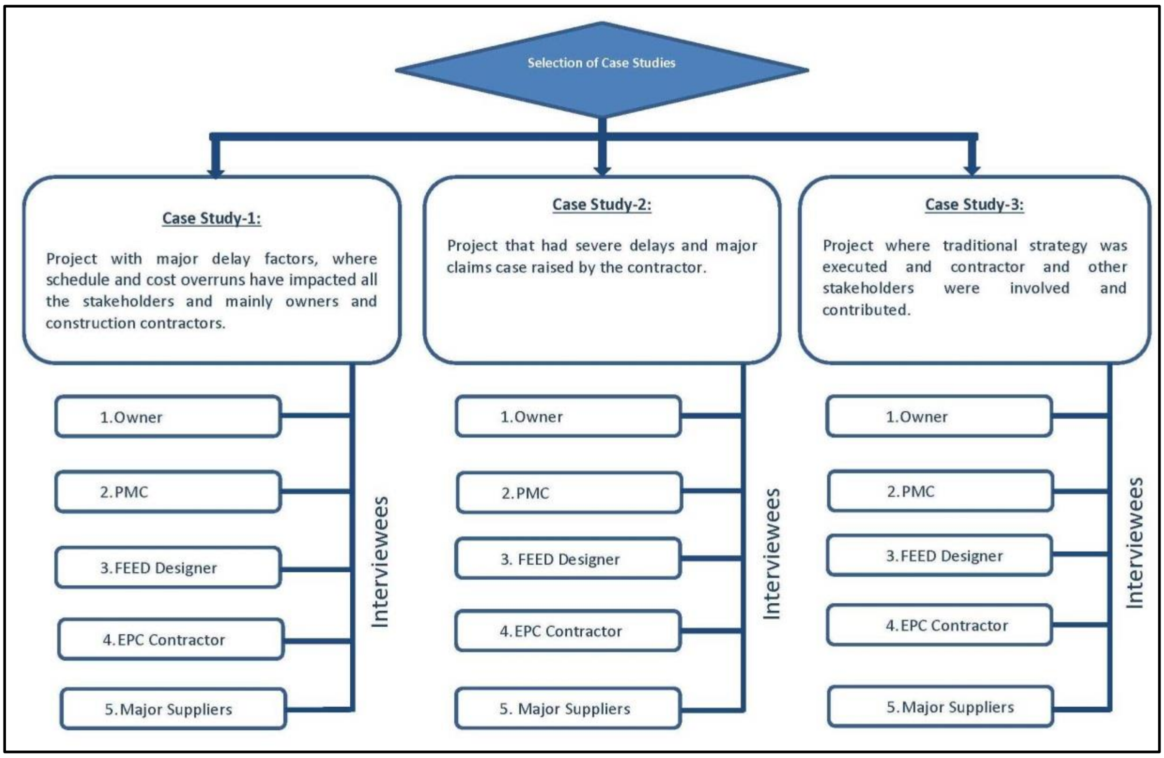


Figure (5.2) Selection of Case Studies

5.2.3. Case Studies Participants Selection Criteria (Interviewees)

The researcher selected three specific projects as case studies. The interviewee's selection criteria were developed to obtain the most benefit from the interview. The selection was based on those who play key and critical roles during the project lifecycle, decision-making role, schedule involvement, cost involvement, continuation during the project phases, technical decisions, development of strategies, contracting involvement and participation at the project closing with end users. Interviewees will be interviewed separately or jointly depending on interviewees' acceptance, availability, locations and organisation. Five to six interviewees as minimum will be interviewed for each case as, Projects Sponsor, Project Manager, Engineering Manager, Planning Manager, Contract Manager, Construction Manager and Operations Managers (client), those are member of key stakeholders as Owner, PMC, Design consultant (FEEED Designer), EPC contractor and major supplier.

These key project positions (leadership team) represent the project decision makers and they usually participate in all project stages; those interviewees also get involved in all aspects of the project such as but not limited to contract, schedule, cost, technical, project management and decision-making. Additional other interviewees may also be invited and interviewed if necessary from all major stakeholders: owner (client side), project management consultant, FEED designer, EPC contractor and major manufacturer/supplier. A minimum of one member from the end users will also be interviewed to present the operation and maintenance concerns.

Project sponsors from the client side play a key role in all of the project life cycle since they are the ultimate financial decision-making authority and set up the strategies and approve any major variations on the contract. In addition, they are the accountable party from the client side. A project sponsor from the consultant also plays the same role, ensuring that the expenditures and engineering objectives are achieved as per the plan. The project sponsor from the contractors' side is a major player since he commits to the client the schedule and is involved in approving extra resources and extra expenditure from the contractor side. The project manager also plays a critical role from the owner, FEED designer, EPC, sub-contracting and manufacturers sides since his full time and close involvement in all the aspects he is the schedule/cost decision-making party with his management. The client project manager is involved in the daily communication and is the focal point for all the project communication. His duties also extended to represent the client front of his senior management and he is the project representative in case of variations or changes to his management. The consultant project manager or team leader plays the same role where he gets involved in the daily work, reviews and all the schedule progress and contracts aspects. The project manager at the manufacturer's side also gets involved in all the technical and financial subjects and issues. The project managers from all of the stakeholders play a key role in the project decision-making and are the key communication links in the project with other parties, therefore interviewing them will provide thorough understanding of the project issues. The engineering manager also plays a key technical role in the client organisation since all of the technical designs and technical approvals falls under his roles and responsibilities. In addition, all technical approvals and technical divisions are within his authorities. The engineering manager in the contractor side also reviews and approves all technical submissions and is the main accountable person in front of the contractor side. The planning manager in the client organisation also gets involved in various decision-making elements. He approves the plan and closely monitors the schedule and identifies any gaps in the schedule. He also alerts the client to any shortfalls and major delay issues. Where the planning manager in the contractor organisation is accountable to develop all the schedule and plans from the contractor to the client side, he also must revise the plans and provide an alternative schedule in the case of delays and impacts. The client contract manager plays a major role to ensure the contract is executed as per the signed terms and conditions. He is also responsible for all of the contract invoicing and is also responsible for ensuring that all of the communication as per the contract procedure and meet the terms and conditions. His role is extended to cover all the contractual issues and claims. He also ensures the progress payments and all the contractual obligations are implemented and the contract is clear enough to avoid any misinterpretation of the contracts terms and conditions. The construction manager closely monitors the project execution and approves all of the progress payments and makes the decisions from the construction point of views from both side client and contractor sides. The client operation and maintenance plays a key role from the design phase till the contract closing and start up and they get involved in all the major design and operational issues.

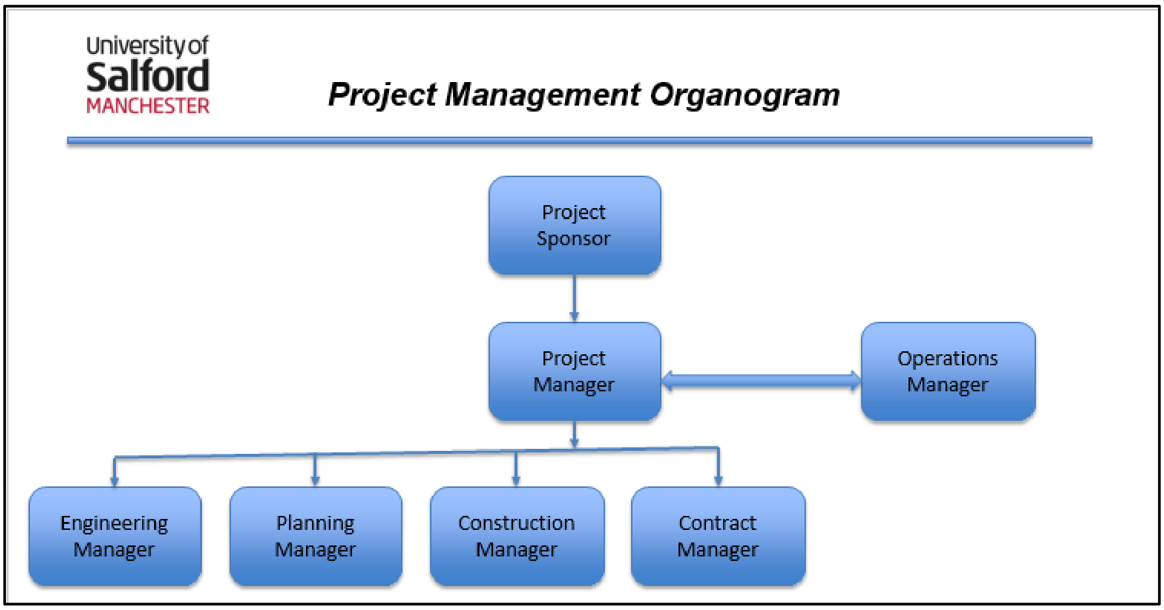


Figure (5.3) Project Management Organogram

5.2.4. Interview Process

The following process will be applied for each interviewee in order to plan the interview in a timely manner.

First step: By phone or face-to-face: seek interviewees' interest to participate and clarify to him the objectives and the nature of this interview. Inform him about the ethical requirement and he needs to confirm via email his interest, explain all the consent form and his right to accept/reject or withdraw and the cover letter.

Second step: Issue an email to confirm interviewee interest officially and advise him about schedule.

Third step: If interviewee is abroad then schedule the interview via email and coordinate the trip accordingly; this will require further planning and coordination, or check if he has any visit to UAE or elsewhere close to UAE then plan accordingly. If the interviewee is in the UAE, then plan via the phone with him and proceed.

Fourth step: Set up interview face to face. During the meeting the researcher will provide a brief on the academic research, survey and the objectives; Request the interviewee to read and agree on the consent form and cover letter, The researcher will explain the performance of project worldwide and the impact on schedule, cost overrun and budget; At a later stage, the researcher will introduce the IPD definitions, approach and the developed initial framework at the end of the interview to minimise the influences and provide the interviewees with flexibility to answer; The researcher will also elaborate how the interview was done with other earlier interviewees and The interview session will be explained as divided into three sections which are: Section A: Common delay factors, Section B: General and Section C: General subjective questions.

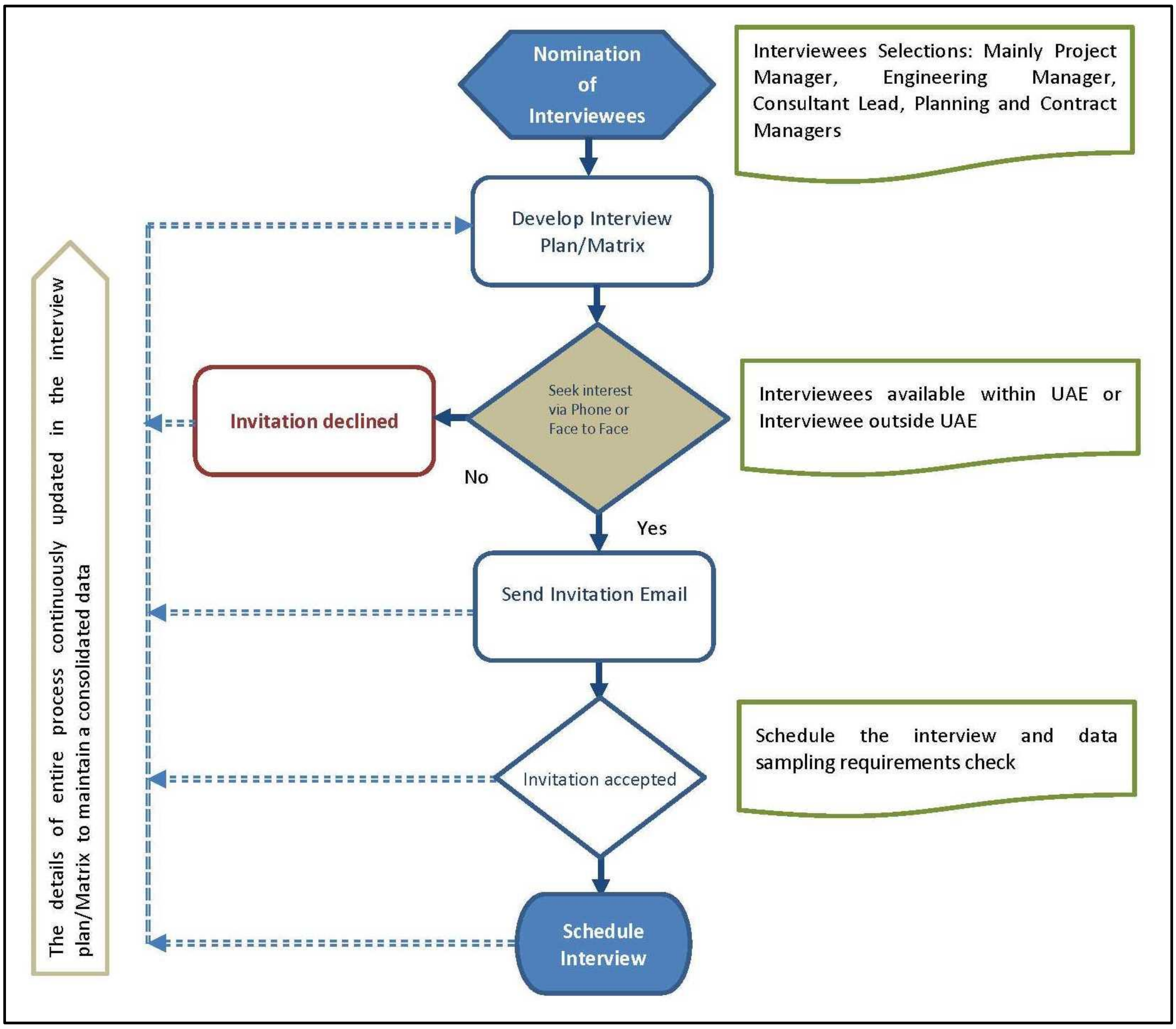


Figure (5.4) Participant Recruitment

Start the interview with section A, then B and lastly section C. The researcher will typically apply the same questions and sections flow with all the interviewees in order to have consistent information gathering and to have typical knowledge sharing. This will help to have smooth interview and typical understanding to the questions. Upon completion of the three sections, each interviewee will be asked whether he has any additional factors that were encountered during his experience on any specific topic or concern to be added.

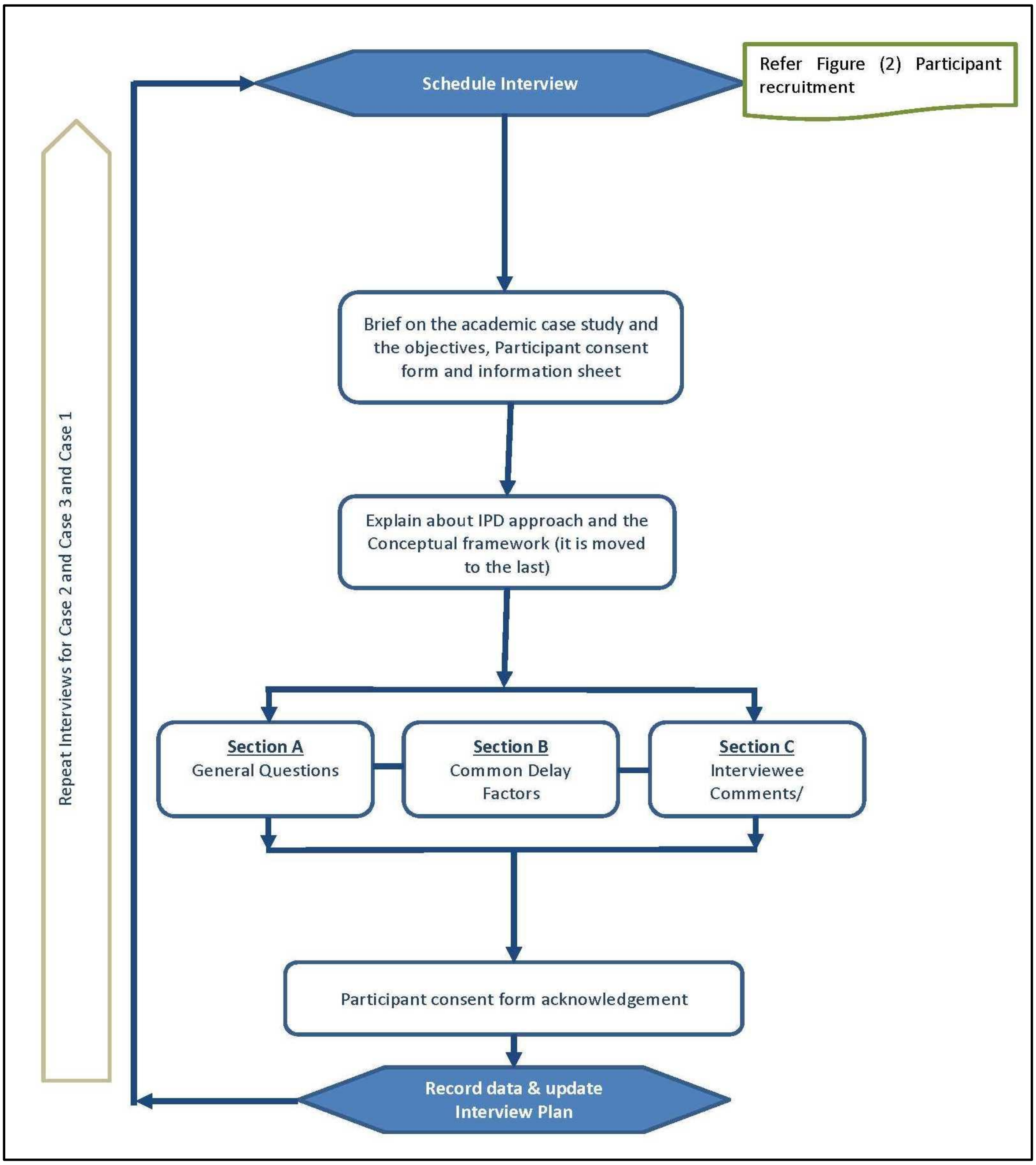


Figure (5.3) Interview Process for Pilot the Questions and Case Studies 1,2&3.

The IPD principle will be presented at the end and the framework and implementation discussion will be kept to the end of the interview, in order to expand the interviewee's knowledge in the challenges and IPD. Collecting the interviewee's comments and feedback on the IPD principle and the initial framework will be discussed further.

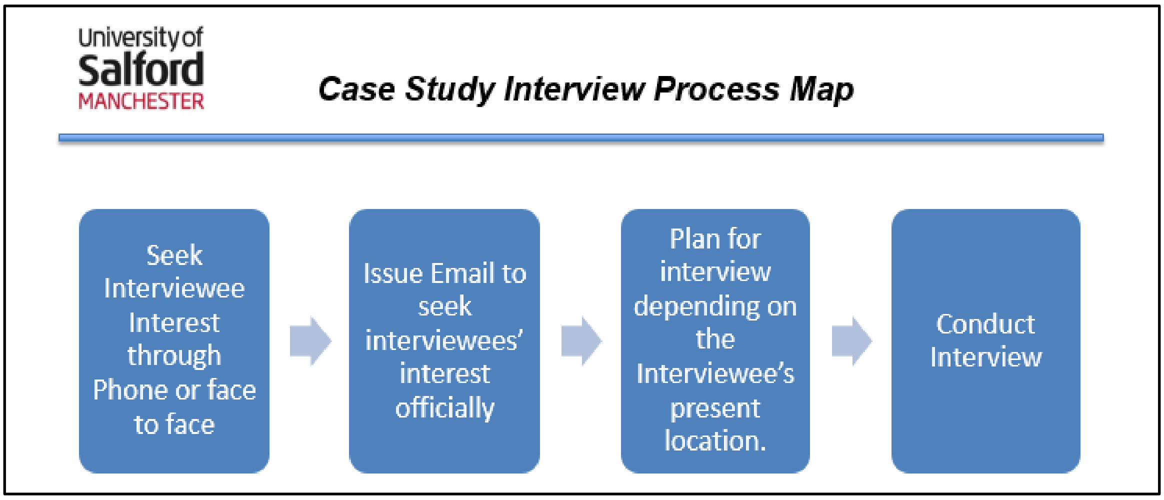


Figure (5.4) Case Study Interview Process Map

5.2.5. Interviews Venue

In order to keep the atmosphere friendly, outside the business influence, formality and to have the interviewees unbiased in their answers, therefore the researcher had scheduled all the interviews outside the business offices and outside the working hours. All of the interviews were conducted in coffee shops. Face to face interviews were also required to understand the interviewees' expressions, give more clarity and ensure better discussion and present the feedback properly. The majority of the interviews where done after working hours.

5.4 Case Study 1

5.3.1 Project Experience

One of the Middle East executed projects "Compression Project" has been delivered with an objective to boost the gas supply to the national power grid to compensate for the shortage of gas supply. Another objective is to sustain a gas supply of more than 1.5 billion standard cubic feet per day (BCFD). This was achieved by introducing gas compression facilities, where the gas is delivered at the middle station with a pressure of 30 bars and boosted to 100 bars then sent to the treatment facilities to power the generation plant.

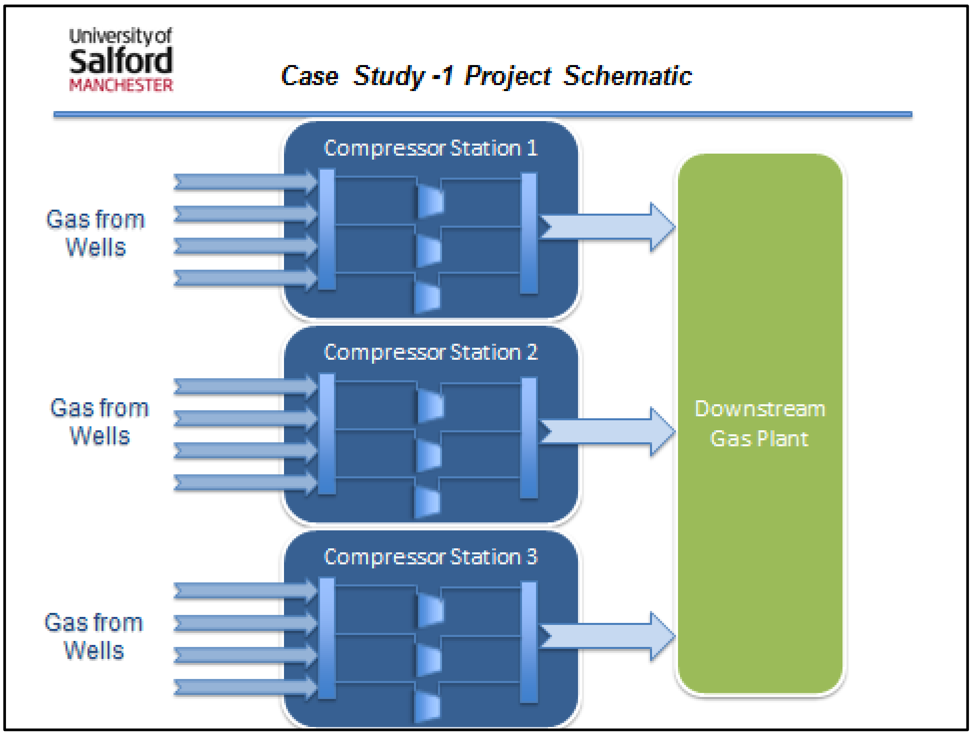


Figure (5.5) Case Study-1 Process Schematic

The project execution strategy of Compression Project was a conventional Design-Bid-Build strategy; where the project started with a normal stage of Select (Concept), Define Stage (Front End Engineering Design- FEED) and Execute stage (Engineering, Procurement and Construction- EPC).

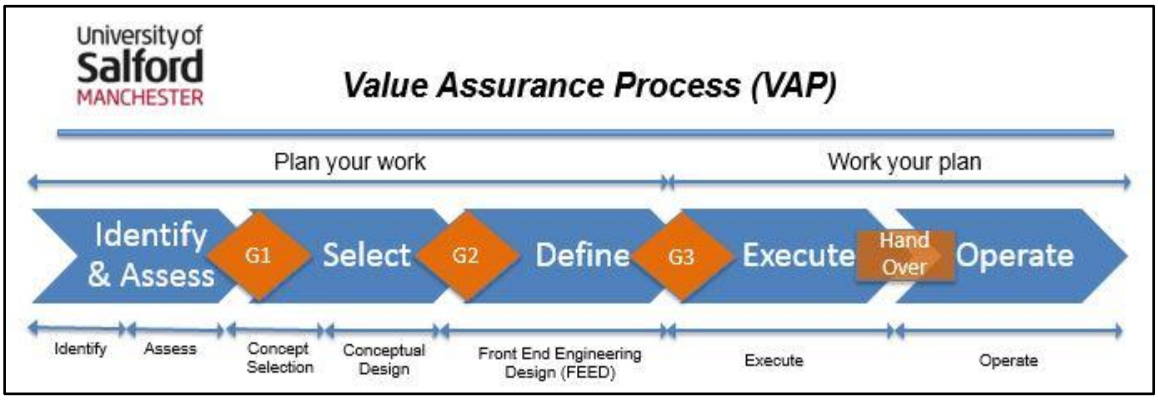


Figure (5.6) Value Assurance Process

Source: ADNOC Value Assurance Book

Concept stages are usually awarded to international consultants such as Washington Group (USA), Flour (USA), Genesis (UK), Mustang (USA), Worley (USA) or Bechtel (UK). These consultancies are well known for handling this type of high level study. Concept's study objective is therefore to select the best feasible option to develop the Compression Project with a duration between four to six months, once the stage of select was completed, then the project moved to the next stage (Define) using conventional bidding award strategy. The project also went into further engineering stages to define all the engineering basis, such as the design basis, standardization, specification, block diagrams, operation philosophies, etc. This stage was called FEED (Front End Engineering Design). Also typical of the Concept study type of the above consultancies are executing the type of FEED project and stage. With such larger-size resources scale and greater man hours, the duration varies between eight to fourteen months to execute each FEED study. This stage (Define) ensures that all the required engineering deliverables are developed to move to the execution stage (construction). The Execution stage is called EPC (Engineering, Procurement and Construction), where the execution contractors (EPC construction) get involved in the bidding process after the FEED study is completed and the owner started the bidding with the project management consultant, where six construction bidders were bidding for six months. This stage took between thirty-six months to forty months to deliver the first product. This mega project involved some major procurement activities for static vessels, gas compressors, exotic pipelines/piping and rotating equipment to handle hydrocarbons. Also the utilities which are required to operate the process facilities, as well as new substations and overhead lines were constructed to provide power to run the plant with utilities. Below are some of the commodities to this project to realise the size and volume of the work; the approximate quantities of commodities executed during the project construction phase is Civil (Concrete): Approx. 50,000 M3, Steel Structure: Approx. 15,000 Tons, Buildings (Concrete): Approx. 20,000 M3, Mechanical: Approx. 8,000 Tons, Piping: Approx. 600,000 ID/12,000 Tons, OHL Towers: about 120 towers, Electrical & instrument Cables: 1,400 Kms. The project recorded an excellent track record of 30 million man-hours with no lost time incidents (LTI).

5.3.2 Project Schedule

The project Concept phase was completed in six months. FEED was done in eight but had to be more optimized with one FEED extension for another six months, and EPC was completed in 43 months including commissioning.

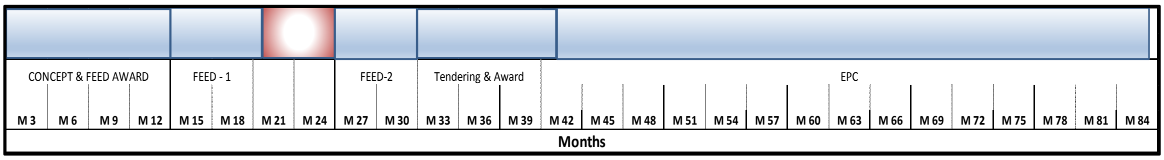


Figure (5.7) Case Study-1 Project Schedule Timeline

5.3.3 Cost

The overall budget of the project was close to 1.2 billion USD.

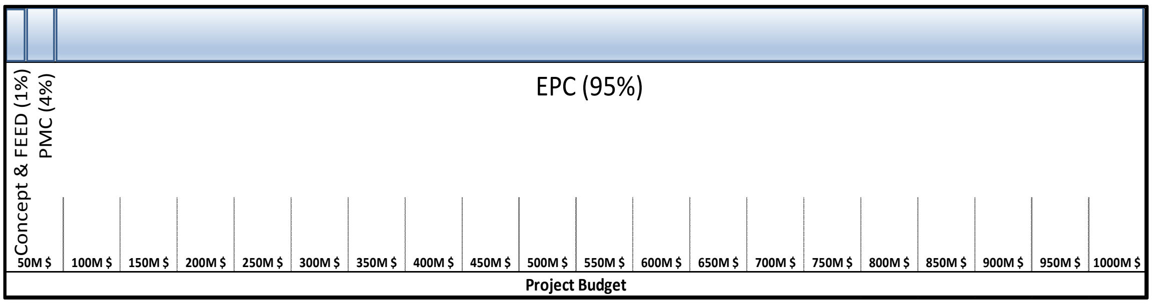


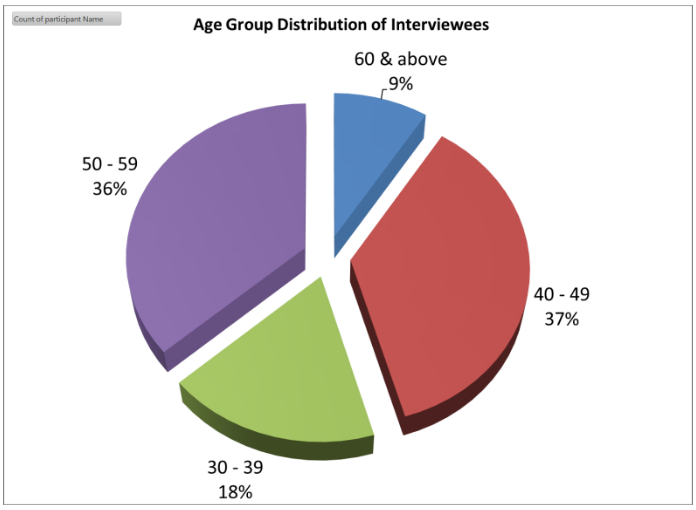
Figure (5.8) Case Study-1 Project Cost Distribution

5.3.4 Key Project Problems (project poor performance factors)

The project was executed with a design-bid-build strategy, where the consultant does not have a communication nor integration channel with the construction contractor, subcontractors or with the main manufacturers. Many factors were behind the project delay and major claim by the contractors, such as conflicts of the drawing and specification, where the FEED used old specifications and a poor review was carried out by the client project team. Design Changes was one of the factors where the owner made several requests to variate from the scope of work and added and deleted scopes which have impacted the schedule. The owner set improper construction milestones, where many activities were to be completed earlier than the realistic plan. There was a lack of integration of skills at early stages of planning & design, and it was notices the poor skills and inexperience of the contractor planning team and wrong estimates of time and cost were made. Materials were changed in types and specifications during construction to meet the schedule and to reduce the cost without obtaining the owner approval which were rejected at site and reordered again. Poor qualification of consultant engineer's staff assigned to the project during the design phase led to poor designing documents and incomplete data sheets, which allowed the contractor to procure low quality systems.

In various systems, overdesign was observed by the construction contractor during the detailed engineering work and the contractor tried to reduce the sizes and make changes to the design document where a big resistance by the owner. Frequent change of project staff was one of the problem in this project since staff continuity affected the progress and the new staff were not familiar with the project history and events. The FEED consultant also used improper codes for the design, where old standards were mentioned in the documents and the owner requested that a new revision be applied. Unrealistic client initial requirements were also an issue since the contractor refused to execute some of the work due to unclear scope of work and there are no exact instructions. Another problem was waiting for information by the owner during the design phase and data collections. During the construction phase the government has introduced a new security measures to improve site accessibilities; this has introduced a new check point gate which has impacted the contractors and caused a daily delay and led to schedule delay and ended up with a claim case by the contractors.

5.3.5 Interviewees Status and Background/Involvement



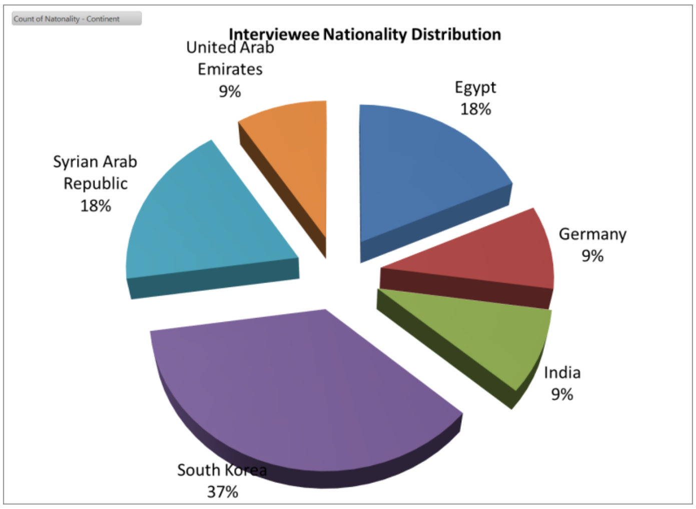
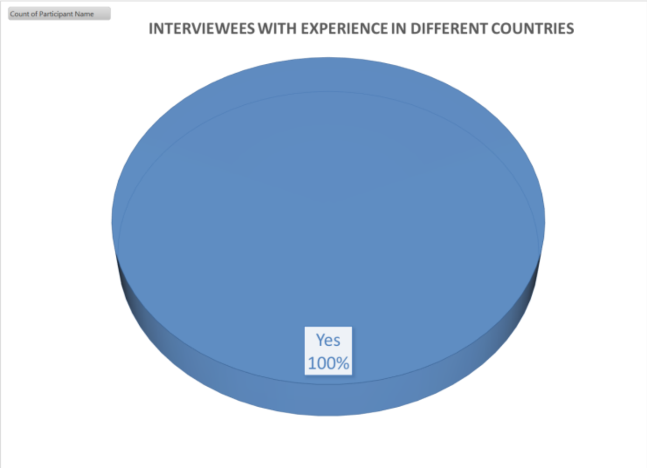


Figure (5.9) Average Age & Nationality Distribution of Interviewees

From this case study, major stakeholders were requested to participate and were interviewed. The interviewed members had worked in different projects and locations; below are some of the facts about the interviewees in the first case study:

It can be seen in the above figure that 39% of the interviewees are of an average age between 40–49, 35% of the interviewees are in the range 50–59 and 9% of the interviewees were above 60 years of age. This indicate that the experience level was high and the interviewees had various degrees of experience and knowledge.

On the other hand, interviewees' nationalities were distributed to cover USA/Canada, Europe, Middle East and Far East with Asia. This presented the mixture of interviewees' culture and social background, which emphasised on the project globe reference and participation.



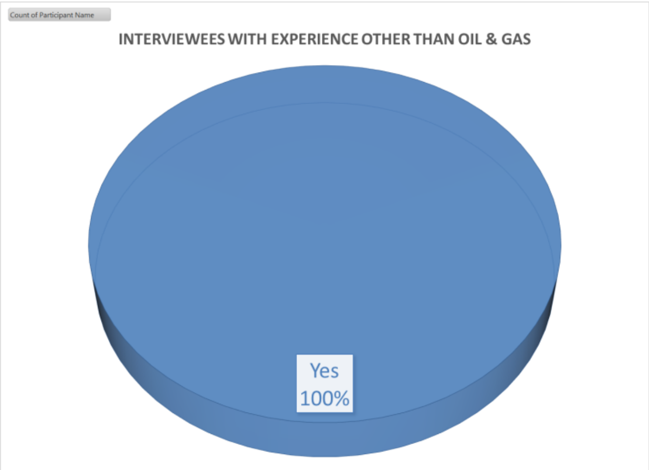


Figure (5.10) Interviewees Experience In Different Countries and Industries Other Than Oil & Gas

As shown in Figure (7.8) above, the majority of the interviewees (about 96%) have experience in more than one country and continent. This will answer whether the factors are related to a specific region or country or if these projects are global in nature and similar in various countries. In addition, it can be observed that 96% of the interviewees have experience in industries other than Oil & Gas, such as infrastructure and power projects. This will answer the question whether the factors and framework related to only Oil and Gas or it can be presented to other industry.

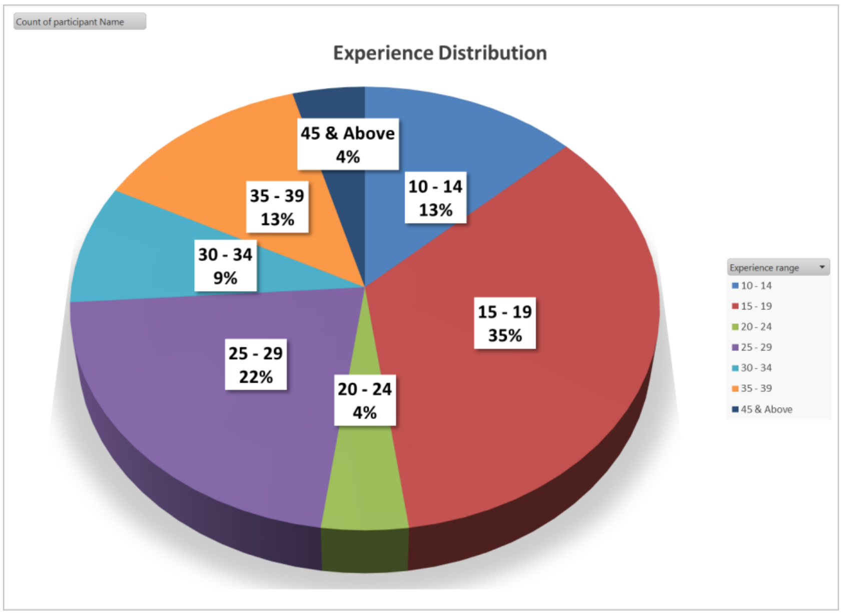


Figure (5.11) Experience Distribution of Interviewees

There is a wide range of overall work experience of the interviewees as shown in the figure above. It was noticed that the interviewees represent a wide range of experiences; they come from different backgrounds and countries, worked in various countries and also worked in various industries other than Oil & Gas. This information assisted to understand and answer several general questions, such as, are the factors related to the Oil & Gas industry or could they be present in general construction too; also could the factors and conceptual framework be presented in the Middle East and UAE or presented in all the regions?.

5.3.6 Interviewees Feedback and Analysis

The interview process and sequence of information/sections were typical with all the interviewees in order to have typical flow of questions; where objective of the research and the subject of the research will be addressed at the beginning, then the poor performance factors, where they occur, who is the main responsible behind them, do they believe that they can be resolved or not, then finally, moved to explain the IPD definition, principle and challenges, then complete the remaining sections of the interview. The IPD explanation was presented last in order to keep the interviewees unbiased to the framework and IPD and it was noticed that the interviewees were interested in the IPD approach and interviewees started asking questions and clarifications on the IPD principles, the age of the IPD, where it was initiated, how many projects had been implemented, and many other questions. Therefore, it was necessary to provide them with more details and request them to defer some of the discussions to the right section and group. The first impression has been taken from the first case. The IPD principles were new to all the interviewees and the first time they have heard about it; however, they tried to link it with similar existing approaches in the Oil & Gas industry, such as partnering, joint ventures or EPCM (Engineering, Procurement, Construction and Management) strategies, where the design consultant carries on as project management consultant during the execution. Also they were interested in asking various questions to understand the IPD in detail.

During the interviews, the interviewees answered the pre-structured questions at the beginning to bring their memories to various factors. Interviewees started to explain the provided questions in their own understanding and events; some of the interviewees started comparing the factors with what he had encountered in the past such as poor management skills. This led them to keep delaying the decisions and ultimately major delays were encountered in the project. Another example was poor designing and inexperience, which led to an unclear scope regarding where the construction contractor took advantage to deviate from the scope. The questions were answered by all of the interviewees. It was noticed that the first five questions were the most difficult to answer by the interviewees due to their slow understanding of the questions; after that they started to answer each question more smoothly.

At the second section, interviewees were taken to answer the questions and helped to fill the forms, it was noticed that interviewees took a longer time to answer the first group of questions (project management); in most of the questions, the answers confirmed the agreement of the presented and identified factors in the literature are poor performance factors and interviewees started expressing various examples of typical problems they have encountered during their experience that they have faced related to the same delay. It was mandatory for the researcher to maintain the interviewees' interest to express their own experienced factors and examples in order to allow them to realise the value of impacts and the need to have a solution. Also the interviewees had taken a longer time to express their own experience with the factors occurrence phases and the factors' responsible stakeholders, in most of the cases the researcher tried to share some of the examples to bring interviewees to the question meaning and various examples were shared and expressed to indicate that factors related to execution may get appear at the design phase and require very early attention. The discussion took much longer to answer whether the literature factor could occur in Design, Tendering or EPC phase, and the discussion took much longer to examine the responsible stakeholders, especially the design consultant responsibility. It was obvious that at later questions the interviewees took a shorter time and started responding faster to agree/disagree on the literature factors and the answers started to harmonise with regard to the occurrence phases; however, the discussion was continued with regard to the stakeholders who are responsible about the delay factor. The researcher was encouraged to maintain the style and interest of the interviewees to express their experiences as far as the time was granted by interviewees and also to keep their passion to answer and have qualitative answers.

The researcher also tried to express other interviewees' feedback, concerns and experiences with some of the factors during the interviews in order to simplify and share other stakeholders' experiences and problems. This style of active and healthy discussion required longer duration for the first interviewees; however, they provided high quality data and responses, which will certainly improve the quality of the research and analysis.

Below the researcher is representing the answers to most of the literature poor performance factors with occurrence phases and responsible stakeholders. The below charts should provide quick overviews and assist in understanding of the delay factors.

5.3.7 First Case Study Results

The first case study was conducted with the inputs from the key role stakeholders representing Client, Project Management Consultant (PMC), Designing consultant (FEED), Major Equipment (such as Gas Compressor) Vendor & Construction Contractor (EPC) and subcontractor in a compression Project executed in Middle East.

The results are plotted in various graphs in order to validate the Factors (secondary) and their collected impact. Based on the inputs from interviewees, the results were carefully analysed to assess their existence, frequency of occurrence and phases of occurrence, in addition to the similarities and to find out the consistency from the perspective above stakeholders.

The results were analysed taking into consideration the following factors:

1. The stakeholders who have participated in the interview look at the project and analyse the delays from their perspective. For example, for a vendor who has got delayed approvals on his engineering documents will assume that the delay is because of delayed client approvals, whereas the actual reason may be improper design in the first place.
2. The above presented stakeholders were involved in different phases of the project and in some of the cases not in all phases of the project due to the Design – Bid – Build strategy followed in the project; however, only the Client

and PMC have the complete project experience cycle through all the phases, therefore the feedback will be based on the participated phase for each interviewee.

3. The natural human instinct to protect one's own interest and organisational interest can influence the responses of the interviewees; however, the researcher tried to share the factors in a project prospective and this condition could impact the responsible stakeholders on the delay, where consistency will be seen in other questions.
4. The interview being repetitive in the nature of questions, with so many inputs, could introduce the possibility of human error while assessing and replying to the questions; however, the researcher tried to ensure that the interviewees were focused and that interviewees' answers were relevant by opening the discussion and by providing some clarification and suggestions with real projects' examples to ease the answers. With the initial data filtering/cleaning it can be assumed that the margin of error will be minimal.
5. The interviewee's global experiences and their execution to various projects in various countries have provided a global feedback and no major specific regional responses were influencing the feedback.

The following graphs were plotted for the first case study based on the interviews' results: Factor (Secondary Data) Validation by Individual Interviewee, Factor (Secondary Data) Validation by Individual Factor, Design Phase Factors (occurrence & resolvable) by individual Interviewees, Design Phase Delay Factors (occurrence & Resolvable) by Individual Factor, Tendering Phase Factors (occurrence & resolvable) by individual Interviewees, Tendering Phase delay Factors (occurrence & Resolvable) by Individual Factor, EPC Phase Factors (occurrence & resolvable) by individual Interviewees, EPC Phase Delay Factors (occurrence & Resolvable Early) by Individual Factor, Factors resolvable by Early Stakeholder Engagement (by individual Interviewees), Factors resolvable by Early Stakeholder Engagement (by Individual Factor), Factors phase of Occurrence (by individual Interviewees) and Factors phase of Occurrence (by Individual Factor).

5.3.7.1 Factor (Secondary Data) Validation by Individual Interviewee.

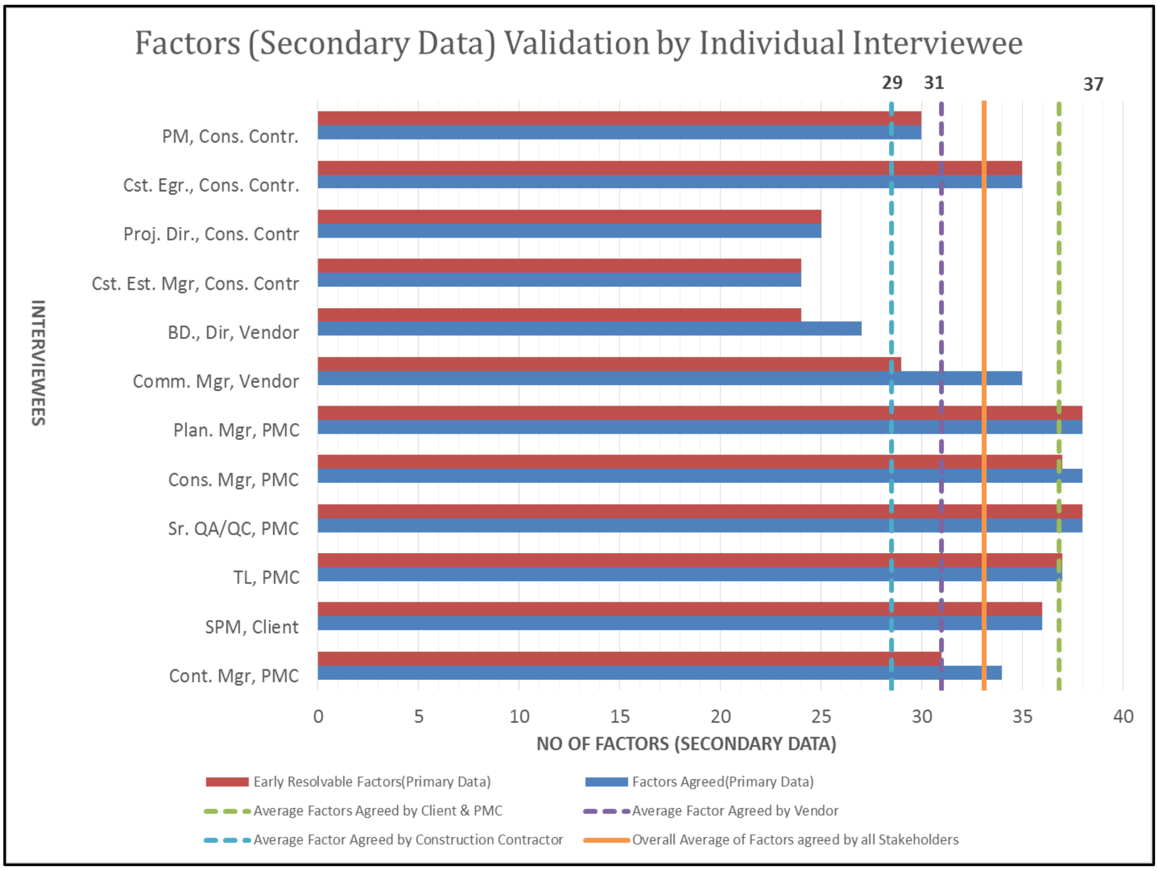


Figure (5.12) Factor (Secondary Data) Validation by Individual Interviewee

The bar chart above shows the factors (secondary data) where interviewees have agreed/confirmed that they are a reason for delay in project and also agreed that the factors whether can be resolved during early design phase. The following observations can be made from the results:

1. On average, it can be read that Client & PMC interviewees have an agreement in a large number, i.e. an average of, 97% of the key factors identified from literatures have agreed into (Secondary Data) (Average of 37 out of 38 factors). It has to be noted that in a Design-Bid-Build execution strategy the client and PMC are the key stakeholders who are engaged in the project from the early design phase till Commissioning. Hence they represent genuine and key response; in addition, a good weight factor is allocated to their response.

2. The client and PMC have also agreed that the majority of these factors are resolvable during the early design phase of the project. About 36 of the 38 factors have been voted resolvable by Client & PMC representatives. This again provides solid and genuine feedback from a stakeholder who has participated in the entire project cycle (phases).
3. Closely following the Client, the vendor representative has agreed to 82% of the factors from the literature (secondary data) (average 31 out of 38 factors).
4. The Construction Contractor has agreed to an average 75% of the factors from literature. It is interesting to note that the majority of the Construction contractor representatives have not considered the following factors as being a major cause of delay in the project (point numbers represent the survey questions numbering):

17. Delay in preparation and approval of documents by Owner and FEED consultant/contractor
27. Outdated design software

5.3.7.2 Factor (Secondary Data) Validation by Individual Factor

This graph below shows the_consistency of responses by all stakeholders for the factors identified from Secondary Data Source. The following observations to be noted from the above:

1. In general, it can be observed from the above graph that where an interviewee has agreed to a factor which affects the project, the majority have also agreed that it is resolvable early during the project design phase, hence the red and blue lines are seen either overlapping or very close to each other, as highlighted by data point 1.

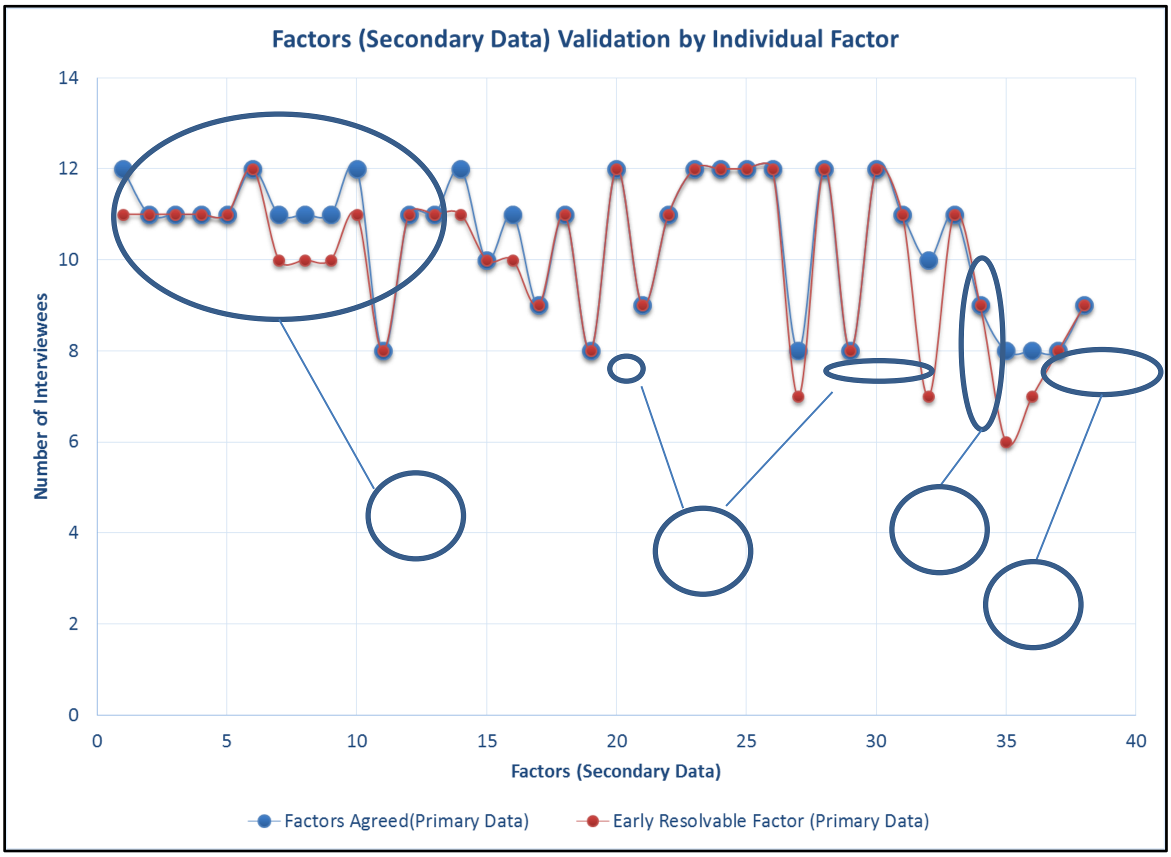


Figure (5.13) Factor (Secondary Data) Validation by Individual Factor

2. The highlighted data points 2 above show that a lower number of interviewees have agreed on the factors; however, the point to be noted is that almost all who have agreed on the occurrence of the factor have agreed that it can be resolved during the early design phase. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):
3. 11. Lack of IT use in communication and information management
4. 19. Mega size, design complexity and complications
5. 29. Delay in tendering and award schedule
6. 37. Limited authority of PMC consultant
7. The highlighted data point 3 above shows the anomaly where 9 of the 11 interviewees have encountered the factor in their past experience but only 7 believe it is resolvable during early design. Hence the factor “Financial

issues of Contractor during execution” as an example has to be given more weight factor during risk assessment in projects.

5.3.7.3 Design Phase Factors (occurrence & resolvable) by individual Interviewees

The graph plots interviewees’ responses on the number of factors which occurs during the design phase of the project and number of factors that are resolvable during early design phase involvement from the stakeholders. The graph also shows the average number of responses on the factors occurring during the design phase of the project as agreed by Interviewees and average number of factors resolvable during early design phase.

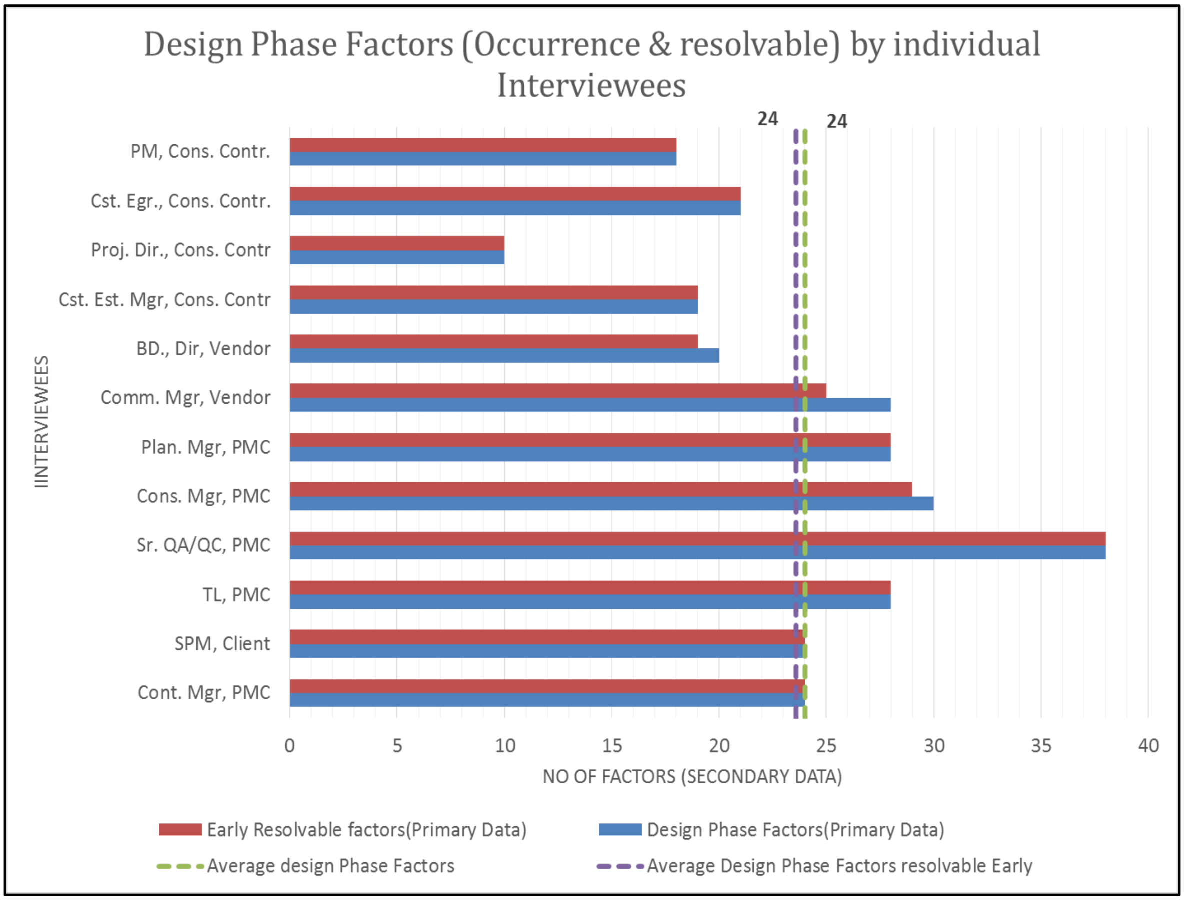


Figure (5.14) Design Phase Factors (occurrence & resolvable) by individual Interviewees

The following observations can be made from the above:

1. Of the factors agreed to be occurring in design phase by the interviewees, they also believe that most of these factors can be resolved during early design phase of the project.
2. On average 24 of the 38 factors (64%) are believed to occur in design phase by the interviewees of which majority have been agreed resolvable early by the Interviewees.
3. One of the manufacturers and vendors have responded that a few of the factors occurring during design phase are less resolvable during early design phase of the project. The main reason being that these factors though occurring early, however the impact of the same is seen by the vendor after substantial completion of his design and manufacturing activity or during the commissioning phase, such as (point numbers represent the survey questions numbering):
4. 9. Issues regarding permissions/approvals from other stakeholders
5. 10. Slow decision-making & lack of staff involvement from owner side
6. 14. Incomplete or inaccurate cost estimate by owner & construction contractors

5.3.7.4 Design Phase Delay Factors (occurrence & Resolvable) by Individual Factor

The graph shows how many of the interviewees have agreed that each factor occurring in the design phase of a project is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project.The graph also plots the interviewees' group (Client/PMC, Vendor & Construction Contractor) average on the number of factors resolvable during the early design phase from the ones agreed to be occurring in design phase of the project. The following can be inferred from the graph:

1. On average, it can be observed that almost all of the interviewees have responded with confirmation that all the agreed factors occurring during

design phase, almost all of them can be resolved during early design phase.

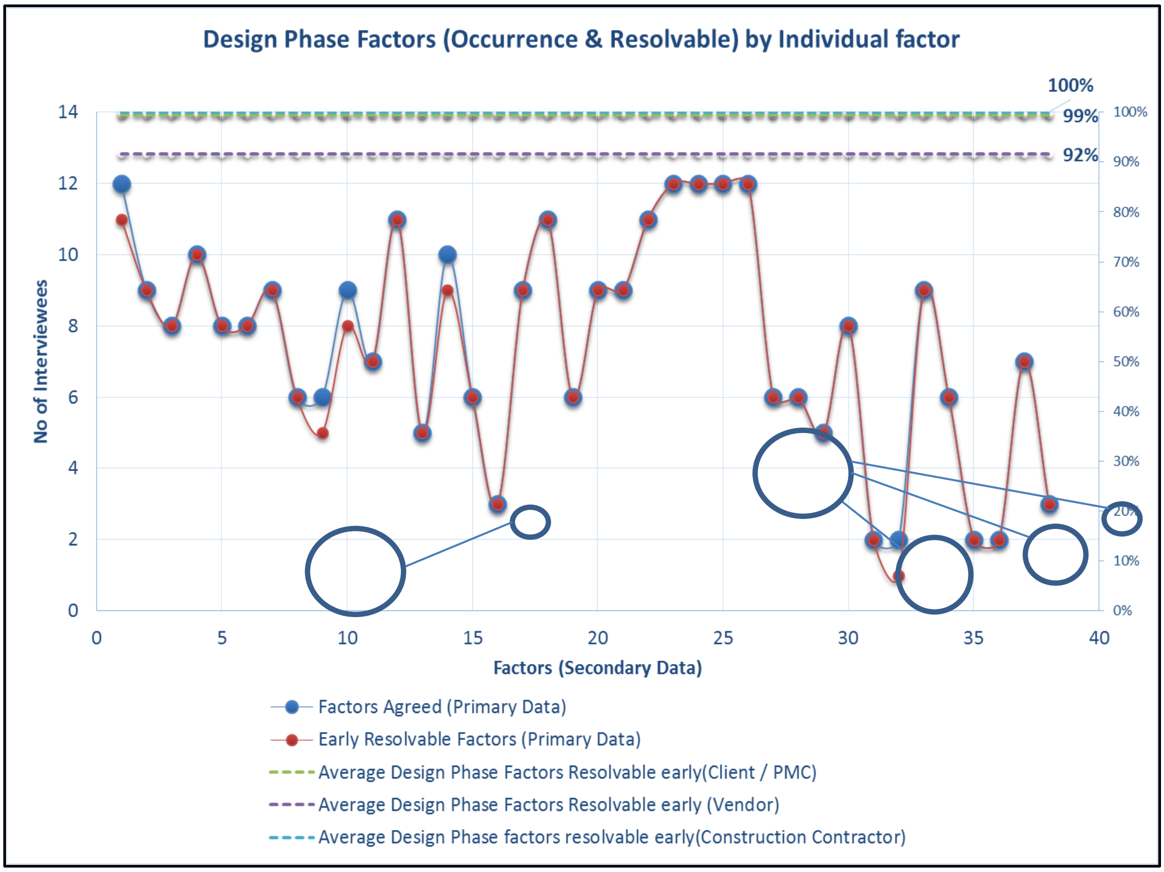


Figure (5.15) Design Phase Delay Factors (occurrence & Resolvable) by Individual Factor

2. As highlighted in the data point-1, some of the factors have been considered to occur less frequently during the design phase by a few interviewees. The majority of the interviewees have considered that these factors do not occur in the Design Phase. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

16. Poor estimation of labour productivity by EPC
31. Delay in procurement by contractor
32. Financial issues of contractor during execution

35. Less time for EPC tendering and too many bidders

36. Limited capability of contractor

38. Poor technical decision during tendering by PMC

5.3.7.5 Tendering Phase Factors (occurrence & resolvable) by individual Interviewees

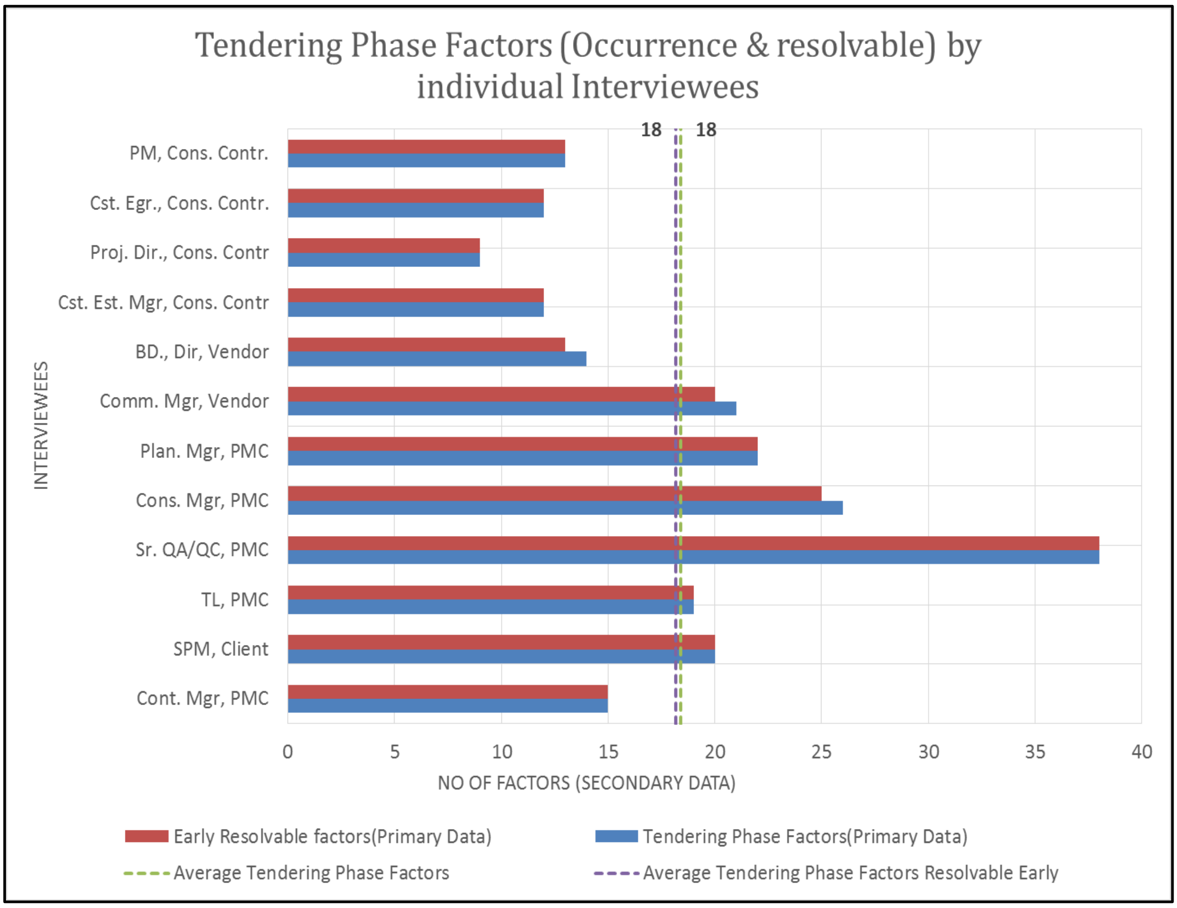


Figure (5.16) Tendering Phase Factors (occurrence & resolvable) by individual Interviewees

The graph above plots interviewees' responses on the number of factors which occurs during the Tendering phase of the project and number of these factors that are resolvable during early design phase. The graph also shows the average number of responses on the factors occurring during the tendering phase as agreed by Interviewees and average number of factors resolvable during early design phase.

1. Of the factors agreed to be occurring in Tendering phase by the interviewees, interviewees believe that most of the factors can be resolved during early design phase of the project.
2. On average, 18 of the 38 factors (47%) are believed to occur in the Tendering phase by the interviewees of which the majority have agreed resolvable early by the Interviewees.
3. It was noticed that interviewees believe that although tendering has an impact on the project delay due to short tendering duration and time limitations, interviewees believe that the tendering phase has less of an impact compared to the design and construction phases.

5.3.7.6 Tendering Phase Delay Factors (occurrence & Resolvable) by Individual Factor

This graph shows how many of the interviewees have agreed that each factor occurring in the tendering phase of a project is a reason for project delay, and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project.

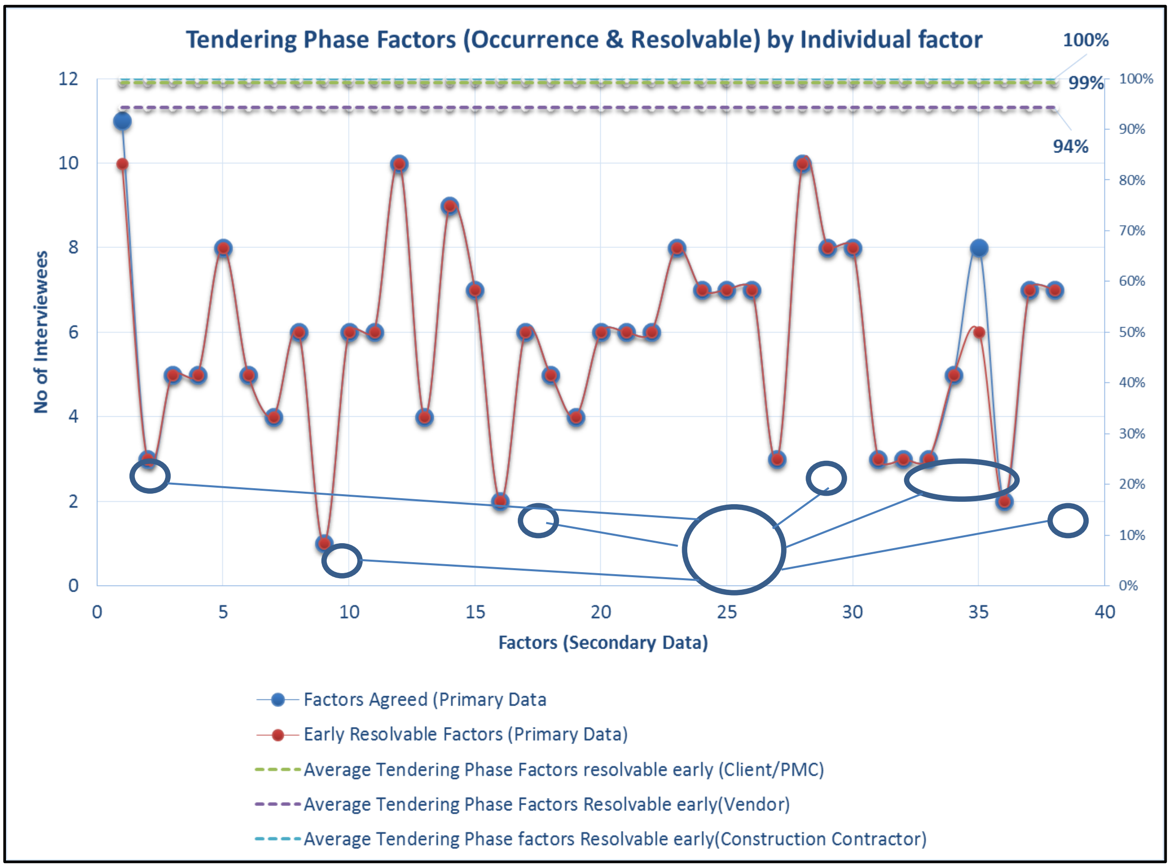


Figure (5.17) Tendering Phase Delay Factors (occurrence & Resolvable) by Individual Factor

The graph also plots the interviewee group (Client/PMC, Vendor & Construction Contractor) average on the number of factors resolvable during early design phase from the ones agreed to be occurring in Tendering phase of the project.

1. On average, it can be observed that almost all of the interviewees have responded that of the agreed factors occurring during Tendering phase, almost all of them can be resolved during early design phase.
2. As highlighted in the data point-1 above, a number of the factors have been considered to occur during the Tendering phase by a few interviewees. The majority of the interviewees stated that these factors do not occur in the Tendering Phase. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

2. Insufficient team building during design and EPC

9. Issues regarding permissions/ approvals from other stakeholders

16. Poor estimation of labour productivity by EPC
27. Outdated design software
31. Delay in procurement by contractor
32. Financial issues of contractor during execution
33. Delay in mobilization during Design & EPC
36. Limited capability of contractor

5.3.7.7 EPC Phase Factors (occurrence & resolvable) by individual Interviewees

This graph plots interviewee' responses on the number of factors which occur during the Construction (EPC) phase of the project and the number of factors that are resolvable during the early design phase if they are addressed properly. The graph also shows the average number of responses on the factors occurring during the EPC phase as agreed by interviewees and the average number of factors resolvable during early design phase.

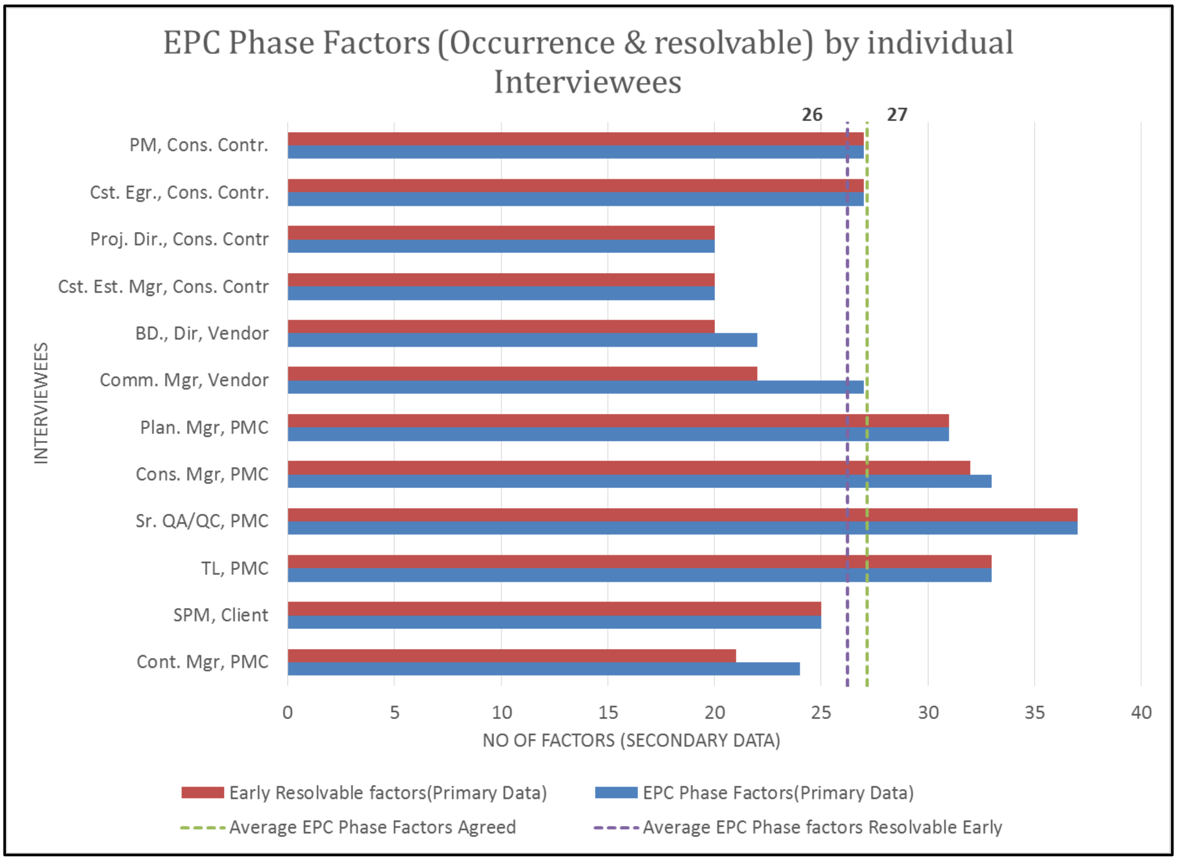


Figure (5.18) EPC Phase Factors (occurrence & resolvable) by individual Interviewees

The following observations were made from the above graph:

1. Of the factors agreed to be occurring in the EPC phase by the stakeholders except for the vendor all the other representatives of Client & Construction Contractor believe that most of the factors can be resolved during early design phase of the project
2. On average 27 of the 38 factors (71%) are believed to occur in the EPC phase by the interviewees, of which the majority have been agreed to be resolvable early by the interviewees.
3. The vendor has responded that a few of the factors occurring during EPC phase are not resolvable during the early design phase of the project. The main reason being that the factors, though occurring early the impact of the same is seen by the vendor after substantial completion of his design and manufacturing activity or during the commissioning phase.

5.3.7.8 EPC Phase Delay Factors (Occurrence & Resolvable Early) by Individual Factor:

This graph shows how many of the interviewees have agreed that each factor occurring in the EPC phase of a project, is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewee group (Client/PMC, Vendor & Construction Contractor) average on the number of factors resolvable during early design phase from the ones agreed to be occurring in EPC phase of the project.

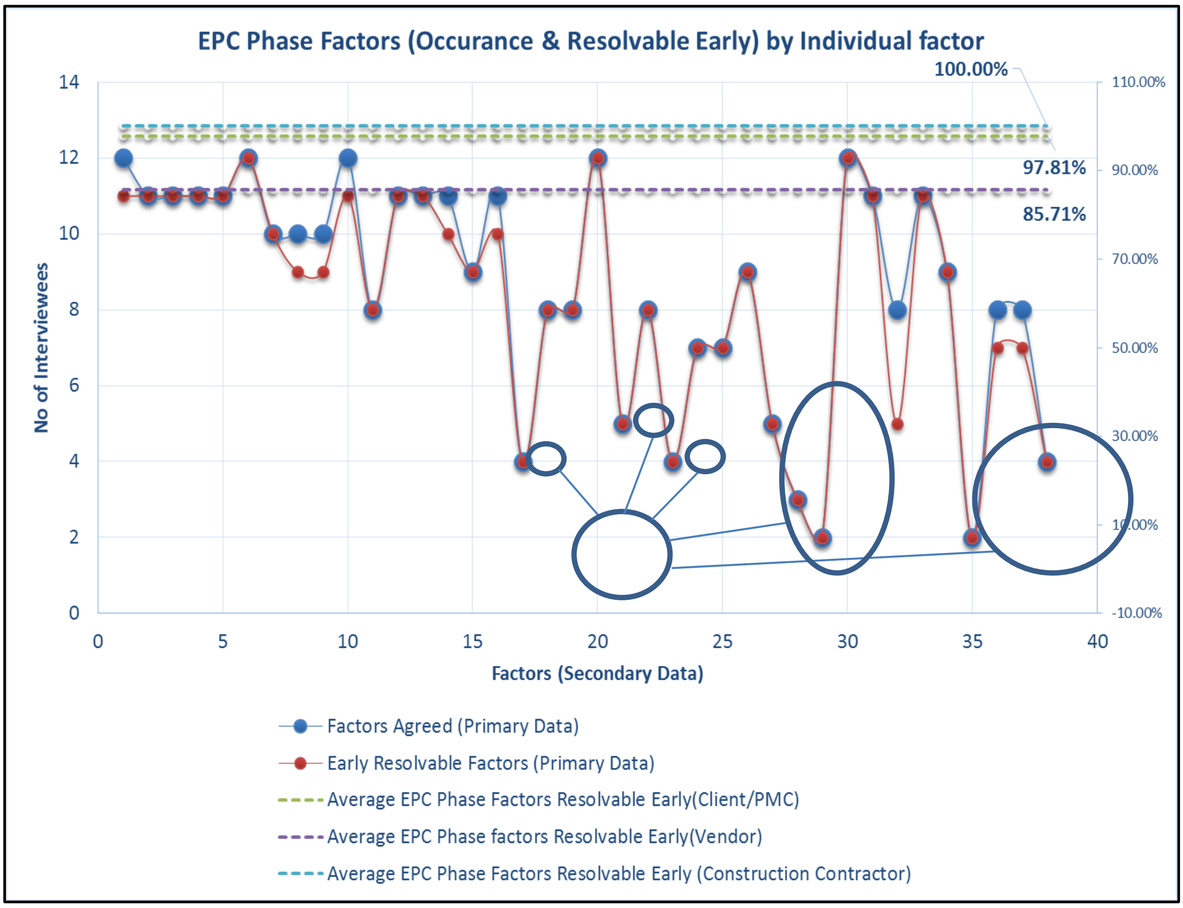


Figure (5.19) EPC Phase Delay Factors (occurrence & Resolvable Early) by Individual Factor

The observations from the above graph is listed below

1. In general, it can be noticed that out of the agreed number of factors by the stakeholder groups an average of 98% factors is considered as resolvable early by client/PMC, 81% of factors is considered resolvable early by the vendor & 100% of the factors resolvable early by the construction contractor. The maximum anomaly can be found in the case of vendor where factors are considered not resolvable early.
2. As highlighted in the data point 1 above, a number of the factors have been considered to occur during the EPC phase by a smaller number of interviewees. The majority of the interviewees have stated that these factors do not occur during the EPC Phase. Below are the factors which fall under this category (point numbers represent the survey questions numbering):

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

21. Inadequate project objective and scope definition by owner and FEED designer

23. Poor quality of deliverables by FEED designer

27. Outdated design software

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in tendering and award schedule

35. Less time for EPC tendering & too many bidders

38. Poor technical decision during tendering by PMC

5.3.7.9 Factors Resolvable by Early Stakeholder Engagement (by Individual Interviewees)

This graph plots the individual interviewee response on the number of factors from the secondary data which occur during the project, number of factors resolvable during early design phase and number of factors which require early engagement of stakeholders for resolving the factors, who generally get involved in the later stages of project viz. construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors.

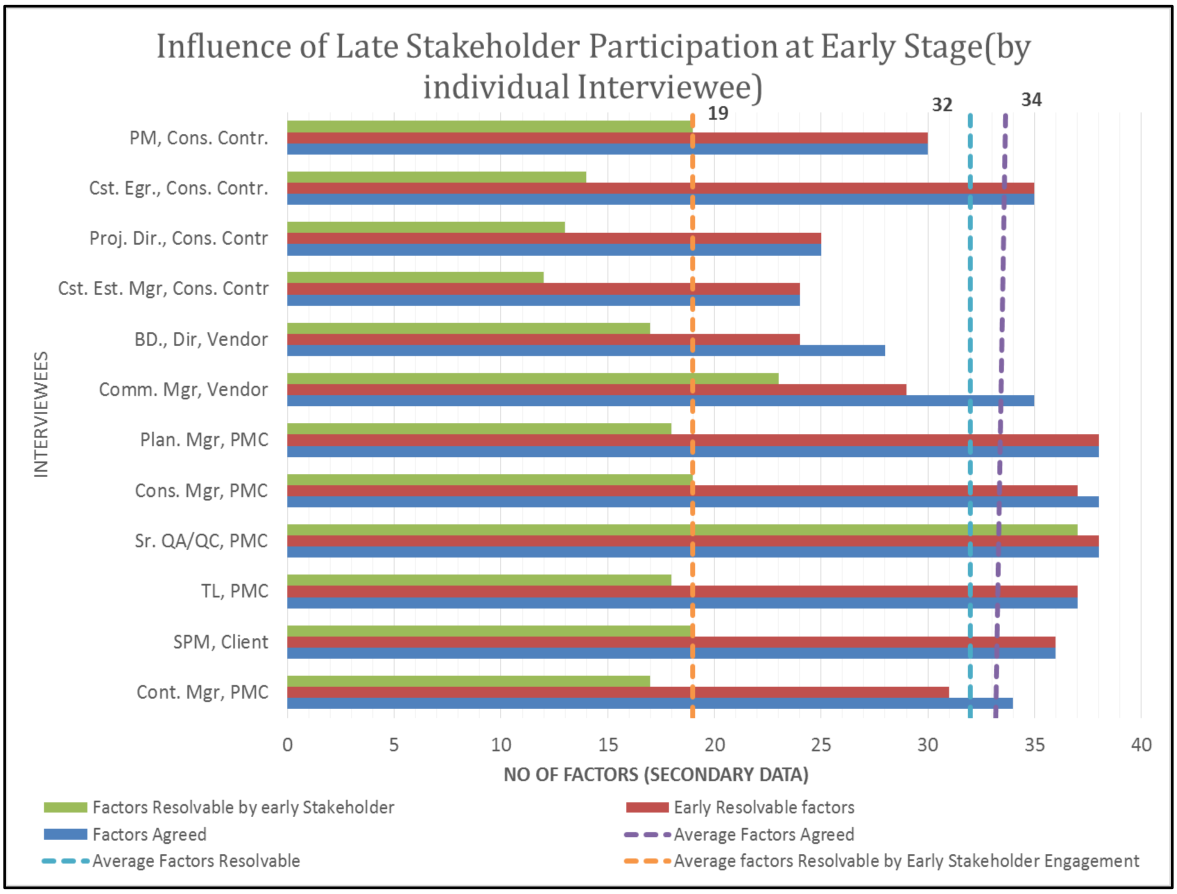


Figure (5.20) Factors resolvable by Early Stakeholder Engagement (by individual Interviewees)

The following observations can be made from the above graph:

1. About 56% of the resolvable factors agreed by interviewees can be resolved by early engagement of late stakeholders during early design phase. These stakeholders are generally identified and involved usually at later stages of the project viz. construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors.
2. About 38% of the factors can be resolved during early design phase without any early engagement of construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors.
3. An overall average of 94% of the factors agreed from the secondary data can be resolved during early design phase.

5.3.7.10 Factors Resolvable by Early Stakeholder Engagement (by Individual Factor):

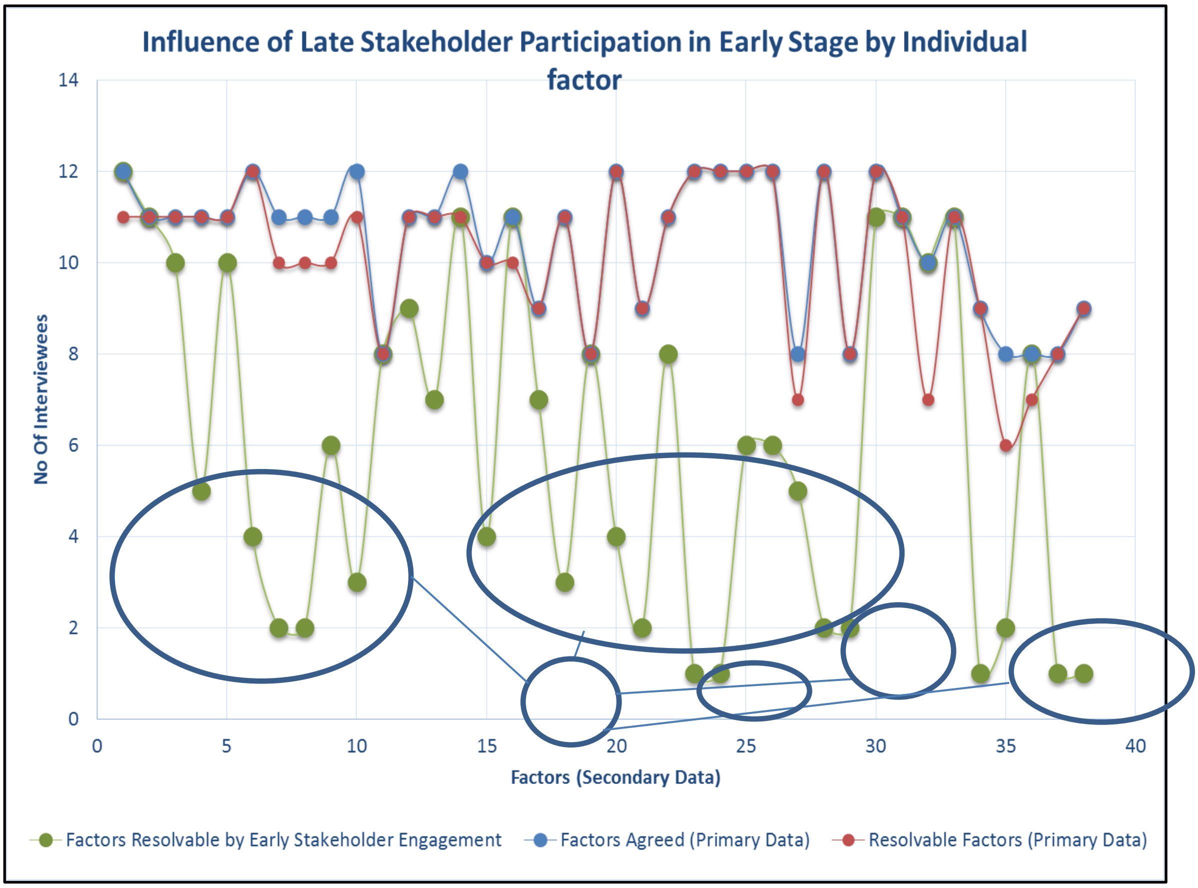


Figure (5.21) Factors resolvable by Early Stakeholder Engagement (by Individual Factor)

This graph shows how many of the interviewees agreed that each factor occurring in Construction (EPC) phase of a project, is a reason for project delay, how many of the Interviewees have agreed that each of these factors can be resolved during the early design phase of the project, and how many interviewees have agreed that each of the factors require early engagement of stakeholders for resolving the factors, who generally get involved in the later stages of project viz. construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors.

1. From data point 1 selected above, it can be seen that a number of factors (approximately 42%) can be resolved without early engagement of construction contractor, major & minor equipment manufacturers and

specialist consultant/sub-contractors, even though early engagement of these stakeholders can improve the quality and schedule. The following are the factors which fall under this category, (point numbers represent the survey questions numbering):

4. Conflicts/disputes between owner stakeholders (project team and operations)
6. Insufficient & inexperienced management personnel from owner
7. Frequent owner interference
8. Excessive bureaucracy in owner's organisation
10. Slow decision-making & lack of staff involvement from owner side
15. Inadequate or improper planning from owner to deliver the project
18. Lack of client participation in major milestones during design
20. Design variations or changes in client requirement
21. Inadequate project objective and scope definition by owner and FEED designer
23. Poor quality of deliverables by FEED designer
24. Delayed or insufficient design information from owner
27. Outdated design software
28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding
29. Delay in tendering and award schedule
34. Flexibility of client to adopt technical changes
35. Less time for EPC tendering & too many bidders
37. Limited authority of PMC consultant
38. Poor technical decision during tendering by PMC.

5.3.7.11 Factors phase of Occurrence (by individual Interviewees):

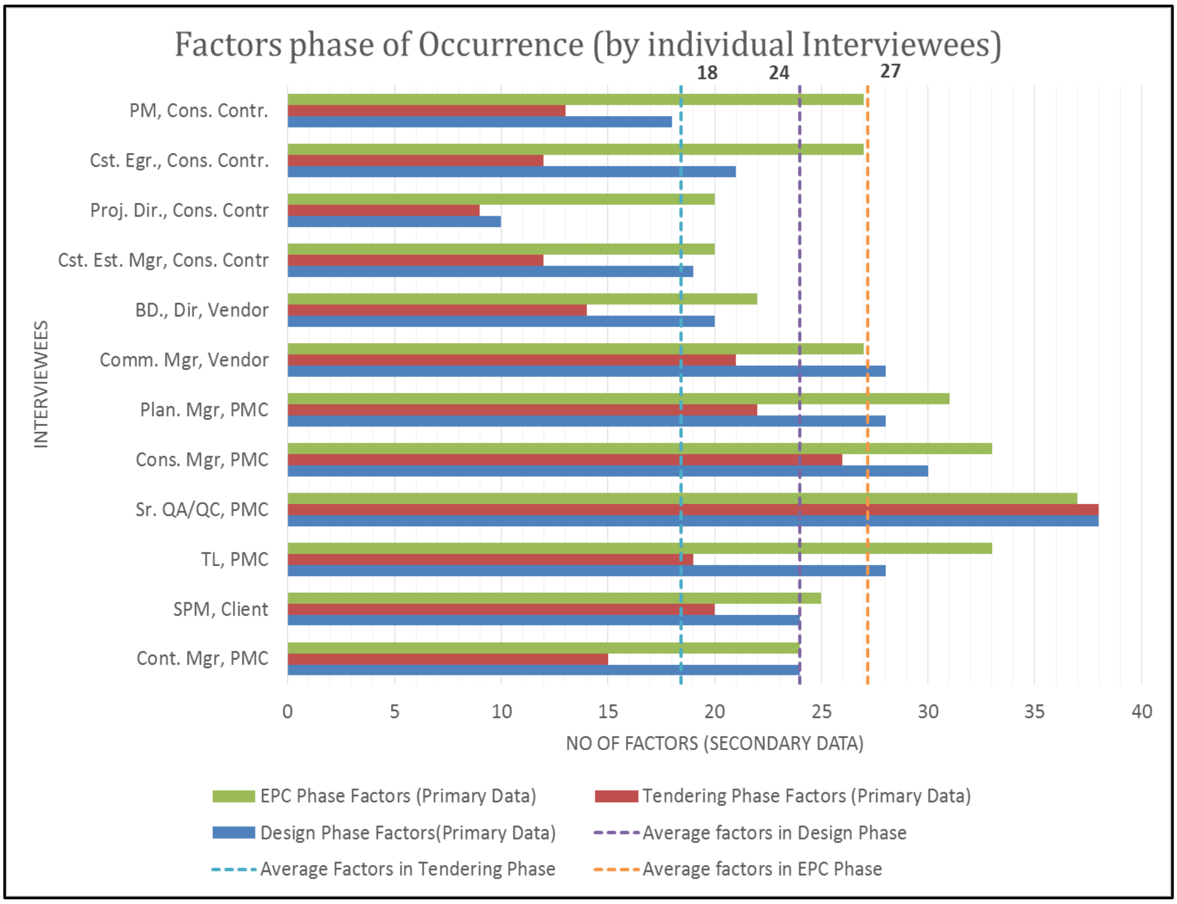
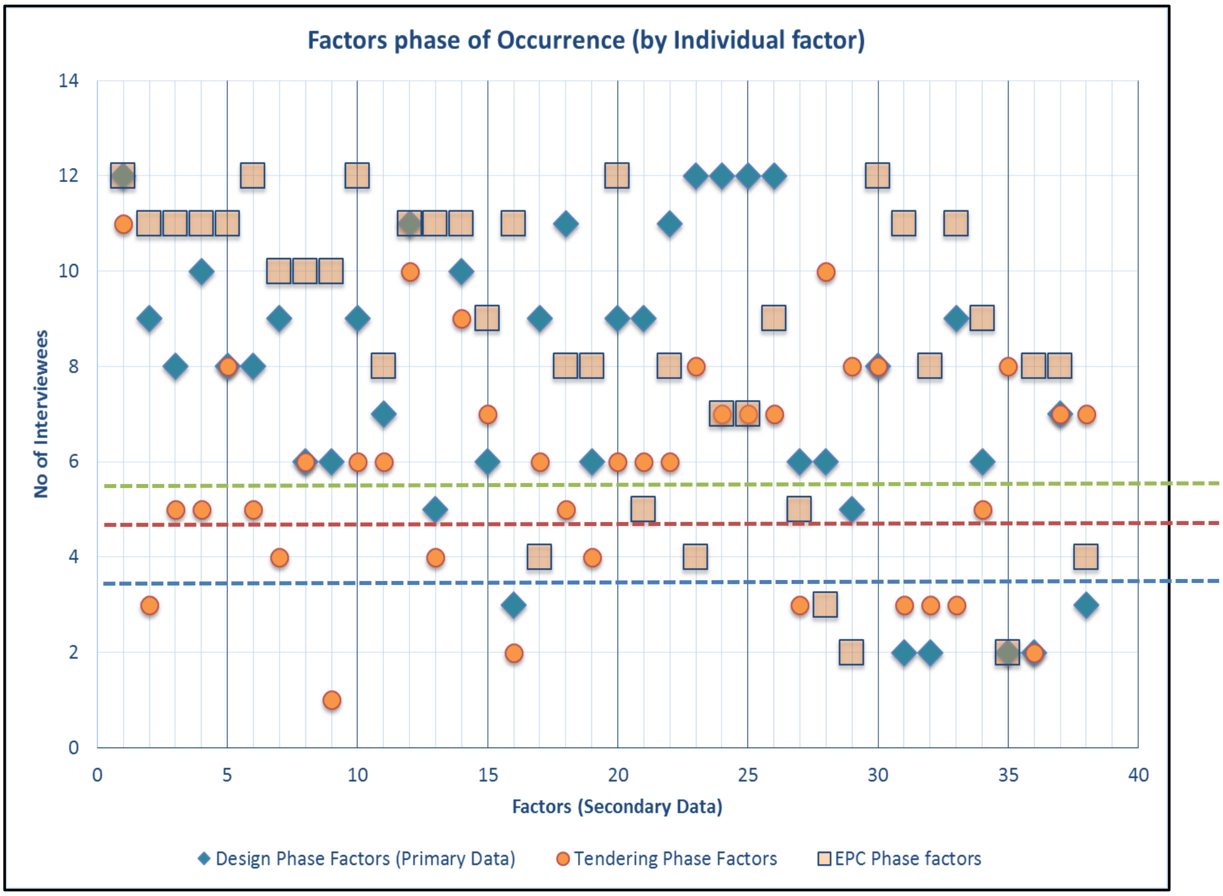


Figure (5.22) Factors phase of Occurrence (by individual Interviewees)

This graph shows by individual interviewee feedback how many factors occur in each phase of the project.

1. Based on the interviewee feedback, about 63% of the delays occur during the design phase of the project; 47% occur during the Tendering phase and 71% occur during the EPC phase.
2. All groups of interviewees (client/PMC, vendor & construction contractor) have agreed on an average the highest number of factors (selected from secondary data) occur during EPC followed by Design and the least number of factors occur during tendering.

5.3.7.12 Factors phase of Occurrence (by Individual Factor):



EPC Threshold Tendering Threshold Design Threshold

Figure (5.23) Factors phase of Occurrence (by Individual Factor)

This graph shows by individual factor how many interviewees have voted that a factor can occur in each of the phases of the project. viz., design, tendering & EPC.

1. From the graph above, it can be observed that very few interviewees have voted for some of the factors which occur in the phases covered by the highlighted region in the graph above, Researcher after referring to each mentioned factor realised that interviewee’s answers are relevant and these factors irrelevant to the phase of the project. Some of the examples for factors not expected to occur under each of the phases are listed below:
2. Factors not expected to occur during Design, (point numbers represent the survey questions numbering):

16. Poor estimation of labour productivity by EPC

31. Delay in procurement by contractor

32. Financial issues of contractor during execution

35. Less time for EPC tendering & too many bidders

38. Poor technical decisions during Tendering by PMC

Factors not expected to occur during Tendering, (point numbers represent the survey questions numbering):

3. Inappropriate overall organisation structure linking all project teams

7. Frequent owner interference

9. Issues regarding permissions/ approvals from other stakeholders

13. Inadequate control procedures from owner side to monitor the progress and delay

16. Poor estimation of labour productivity by EPC

19. Mega size, design complexity and complications

27. Outdated design software

31. Delay in procurement by contractor

32. Financial issues of contractor during execution

33. Delay in mobilization during Design & EPC

36. Limited capability of contractor

Factors not expected to occur during EPC, (point numbers represent the survey questions numbering):

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

21. Inadequate project objective and scope definition by owner and FEED designer

23. Poor quality of deliverables by FEED designer

27. Outdated design software

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in Tendering and award schedule

35. Less time for EPC tendering & too many bidders

38. Poor technical decision during tendering by PMC.

During the piloting and first case study, the initial framework principle was discussed and examined heavily with the interviewees, especially the piloting experts, where they tried to challenge the framework and expressed some improvements and implementation methods. Both the piloting and first case study interviewees at the beginning had found it difficult to read the framework and to understand the structure; however, after demonstrating the factors distributions and stakeholders' axes along with the project phases axis, the framework was easier to be understood and the same was acknowledged by the interviewees. Interviewees were very keen to propose improvements and to know the result of first implementations. The key discussion on the framework was on how to bring the execution stakeholder (construction Contractor) to participate in the design phase during the FEED stage and how to identify the Construction contractor while the bidding for execution (EPC) would not have started. Hence the question was from the majority of the interviewees that how to identify the construction bidders and which ones will be invited in the FEED.

The IPD principle was not mentioned to the interviews at the beginning to keep them neutral and the discussion goes without influence of the IPD; however, at later stage the IPD was explained.

Also, the key concern from some of the interviewees during both the first case study and piloting was to digest and understand the role of the construction contractor during the participation in the design phase. They assumed that the execution contractor will have the role of designing on behalf of the designing consultant (FEED consultant), which will lead to major conflict and dispute between the designer and the participated contractors. Also contractors may influence the design by proposing their own ideas and design, which could be biased and against their other competitor contractors, also each contractor will propose/impose his own design, i.e. more the number of execution stakeholders participating during the design more conflict and high disagreement between all the participants would be seen since each execution contractor will try to sell his own ideas, principle and design, the same was expressed with the manufacturers' participation; i.e. if there is more than one manufacture for each system to participate during the design phase, then each manufacture will try to sell his own design and product and weaken the advantages of the other competitors.

The other concern raised was how many participants will be involved from each contractor i.e. if six contractors are bidding, then how many persons will be involved from each contractor; this question was raised to extend the worry on the participant's size during the design phase which will be huge and will cause longer discussion and unfocused results, also this will lead to longer design duration. Interviewees' impressions and apprehensions were healthy and genuine too, since if each execution contractor will impose his own interest and ideas, then no consensus or healthy environment will be practised during the early involvement and the quality of the design will not be met with a biased behaviour could be seen from the designing consultant and alliance could be seen between stakeholders against others.

Upon collecting interviewees' concerns and allowing them to address their feedback, the researcher tried to extract and record all of the interviewees' concerns and then started to clarify each problem. Practically, the researcher tried to express the role of the construction contractors during the design phase and explained the improvement that could be done by his involvement, and emphasised that the construction contractor's role is not a designing role nor to impose/sell contractors own ideas, rather, reviewing and providing technical comments and feedback on a designing documents which was developed by the designing consultant and reviewed and approved by the client. In addition, the contractor's role is to identify any uncertainties or shortfalls in the design documents which will have a major impact on his proposal and costs; moreover, from procurement and construction points of view, his role is to propose factors to improve the design quality and minimize the risk on the bidding, detailed engineering and construction phases during the execution phase. Once the interviewees understood the role of the contractor's participations and the objectives, they started to be in consensus and to agree to the advantages and benefits of contractors' participations as far as they will not have a role to influence their own interest and designs.

On the other hand, the interviewees were challenging the control and management of a big number of execution contractors' teams participating during the design, if all will be required to participate in the design phase. Also the interviewees, due to their wide experiences and intensive knowledge in the oil & gas industry, reacted widely to the IPD principle and started challenging the framework implementation strategy and coming up with various proposals and ideas which could be utilised for implementation purposes once the IPD was proposed at a later stage. The most challenging point was how to accommodate the large number of disciplines from each contractor side and how to accommodate all contractors' bidders in one place with different ideas and interests. Interviewees expressed their other problems such as what if some bidders would withdraw and others would be interested to bid but did not get involved in the design phase. The researcher explained since the objective of IPD is to improve the integration during the design and level up the communication between all project's stakeholders with other many advantages, there are many ways to control and manage the construction contractors and number of participants. The researcher also explained that it is not necessary to seek all the execution contractors' participation; as an example, one contractor could represent all of the execution contractors' role and one can address all the concerns on behalf of other bidders, since the objective from having the contractor is to review the design from the contractor point of views and to provide the opportunity to identify any unclear scope or incomplete design. The contractor could identify many gaps which impact their pricing.

There are also other approaches to overcome this issue, such as all the design documents can be sent to many contractors as needed for review and comments while they are in their home office to review and comments the design documents, i.e. contractor disciplines can be added to the project RACI matrix (Responsible, Accountable, Comments & Information Matrix), where each designing document is controlled and known where, when and to whom it should be sent and for approval, comments, review or information only. One more approach is to seek specific disciplines (mechanical, civil, electrical, process, control, etc.) from each contractor rather than asking each contractor to provide his full team to participate during the design, i.e. if five contractors are interested in participating along with designing consultants, clients and other stakeholders, then we may ask each contractor to participate with one or more members like mechanical, civil, instrument, process, piping, pipelines, etc. The last example is that in the Oil & Gas designing phase, there are key designing documents (deliverables) which could impact the cost and schedule of the construction contractors and all contractors are keen to have them with high quality and details, such as, Process Flow Diagrams (PFD), Piping & Instruments Diagrams (P&ID), Heat material Balance (HMB), Material Selection Diagrams (MSD), Long Lead Items (LLI). These designing documents have key value in terms of cost and delivery schedule, therefore contractors can be invited to participate in various review workshops to present their concerns, improvements and close uncertainties in these designing documents. Hence, interviewees convinced that contractors' role and participation could be limited to key project milestones and design documents, particularly those where they have a major impact on schedule and cost. They could be identified early in the project then contractors could participate in reviewing and commenting on these designing documents rather than full-time participation.

Another proposal was to conduct specific design workshops among all stakeholders and maximize the participation from the contractor and manufacturer side. These workshops could be such as a PFD design review workshop, P&ID design review, HAZOP/HAZID, plot plan, equipment layout, value engineering, 3D modelling design workshops, etc. where key technical contractors' disciplines can fully integrated and participate to review these designing documents. The IPD implementation strategy can be discussed further with advantages and disadvantages in other section or research.

The interviewees acknowledged that the majority of the factors can be addressed and resolved during all stakeholders' participations and then they proposed that the framework should reflect the overlap between the phases since the post participants will be involved one stage/phase earlier, where their participation will improve contractors' awareness, knowledge and provide them with all the necessarily data to improve their cost, schedule and minimize execution challenges. Also the contractors will have direct contacts with the designing consultant and client designing members, hence contractors would understand the history, sequencing and designing concerns and problems.

On the other hand, the pilot interviewees requested to reflect the piloting result in the framework in terms of factors restructuring, where some of the factors were combined, others where added, deleted or expressed in other terms. Also it was proposed that the framework may group the factors into designing related factors, communication factors and planning factors to provide more visible, specific, and tangible advantages. The researcher decided to defer this amendment till the remaining case studies are completed and all the comments and feedbacks from all the participants are collected and captured in order to obtain the feedback on the initial framework from all the interviewees and to share and seek consensus on the first case study and piloting feedbacks and improvements prior any amendments.

Interviewees also suggested expanding the initial framework to cover the concept design phase by inviting FEED designing consultant to participate also earlier to improve the conceptual design and obtain intensive awareness and understanding to the project objectives and early problems. This will also be addressed and shared during the next two case studies interviews.

Interviewees also clarified that the framework requires EPC contractors to be invited as early as possible during the FEED design and that this requires an expression of interest, and a bidders list and award strategy should be approved by the owners in order to facilitate their participation. The researcher agreed that all of the EPC bidders must be invited as early during the FEED to secure their participation. Other interviewees expressed that the EPC contractor would spend valuable man-hours to improve the design and to participate; this required dedicated persons from each contractor to participate full-time whether in the designer office or in the contractor office; therefore, it was suggested that the owner bear and pay some incentives to the contractor to participate and to provide potential candidates in the design phase. The cost of two to three engineering and project persons is to be borne by the owner to contractor to ensure full involvement; this cost can be paid for every contractor who is participating to the end of the tendering i.e. to the commercial submission. That value should not be given for the awarded contractor but to be given to the other unsuccessful bidders.

One of the interviewees also suggested modifying the framework to reflect bidders instead of EPC contractors from the FEED phase to the EPC award phase, since the framework shows one EPC bidder which the contractor is not yet awarded. This is a true and valid statement and the researcher modified the framework to reflect this correction.

It was acknowledged by all of the interviewees that EPC contractors and manufacturers' participation is valuable and will improve the design in various aspects and the discussion and variance was on the implementation methods as explained above. Interviewees were very keen to participate in a major project with this framework and were very encouraged by the result. One of the conclusions was the role of the owner to improve the EPC bidders' participation and manufacturers during design, as far as the owner is committed to improving the design as far as the designer and the EPC contractor along with manufacturers, subcontractors and others will be serious and responsible to constructively participate and add value to the design.

It was also mentioned by some of the interviewees that this participation with shorten various project period, and mainly the EPC bidder approval which should be done during the design and approved early doing the design. Also the EPC bidders' familiarisation with the scope of work will be much ahead compared to the previous normal bidding phase, where the EPC bidders receive the Invitation to

Tenders during the bidding phase. However, by this framework the Invitation to Tenderers will be issued much earlier and this will definitely shorten the bidding period and EPC bidders will have sufficient time to issue various queries to major manufacturers and subcontractors very early during the design, so the period of bidding could be improved massively.

The same improvement could be seen from the detailed designing phase by the EPC contractor, since the design uncertainty will be improved and the designing phase will take advantage of this improvement and could complete the detailed designing phase earlier than the conventional phase. This was highlighted by some of the interviewees and they were happy with this assumption and believed that there are other advantages that could be seen from the framework.

Another disadvantage was also expressed by interviewees regarding their potential worries on the interest of EPC to bid during the design phase and how serious are they to participate. Another concern was how to identify the key manufacturers to participate; this was one of the issues where the researcher expressed various options to be considered, one of them being to identify the critical equipment during the early design and invite the manufacturers to participate or to identify the critical path items and invite the manufacturers to participate or identify some of the long lead items then invite the manufacturers to participate. It was raised that the manufacturers should not impose their own design or restricts other competitors to participate. This concern was valid and noted by the researcher and should be addressed during the participation.

5.5 Case Study 2

5.4.1 Project Experience

"Oil Production Facility Upgrade Project" was executed with an objective to increase production of 40,000 barrels of oil per day (BOPD) sustainable production at one of the onshore fields in Middle East. The production increase also requires to drill new 24 oil producer wells and drill 29 water injection wells to increase the reservoir pressure. The scope was extended to upgrade and debottleneck the existing central degassing oil production station.

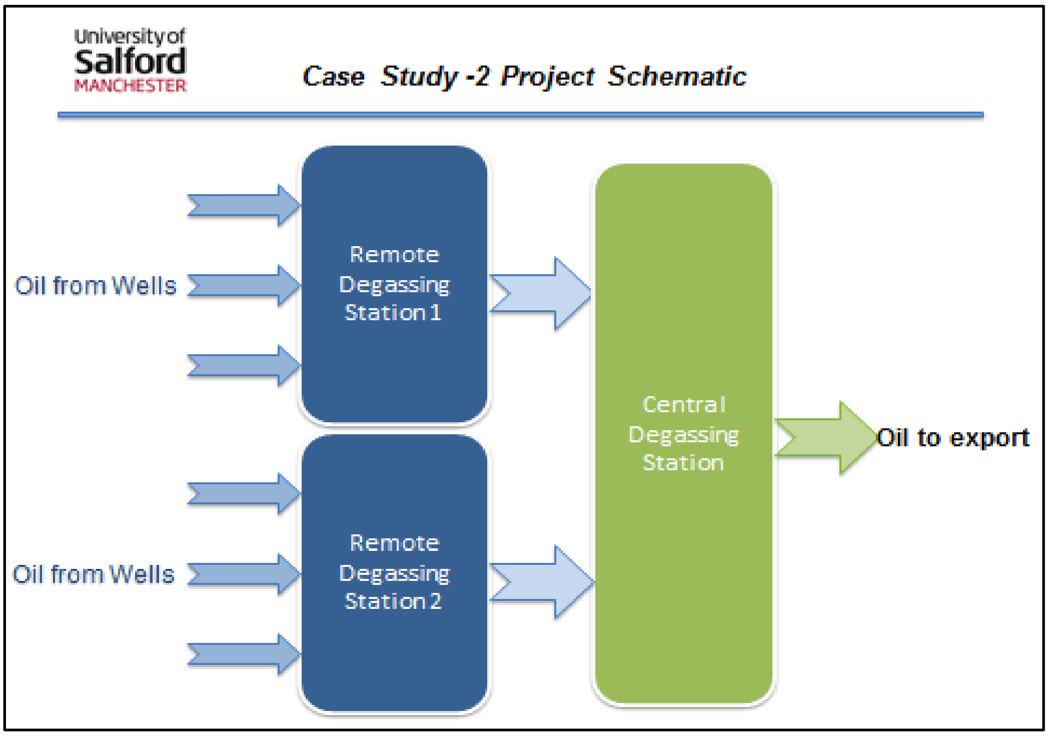


Figure (5.24) Case Study-2 Process Schematic

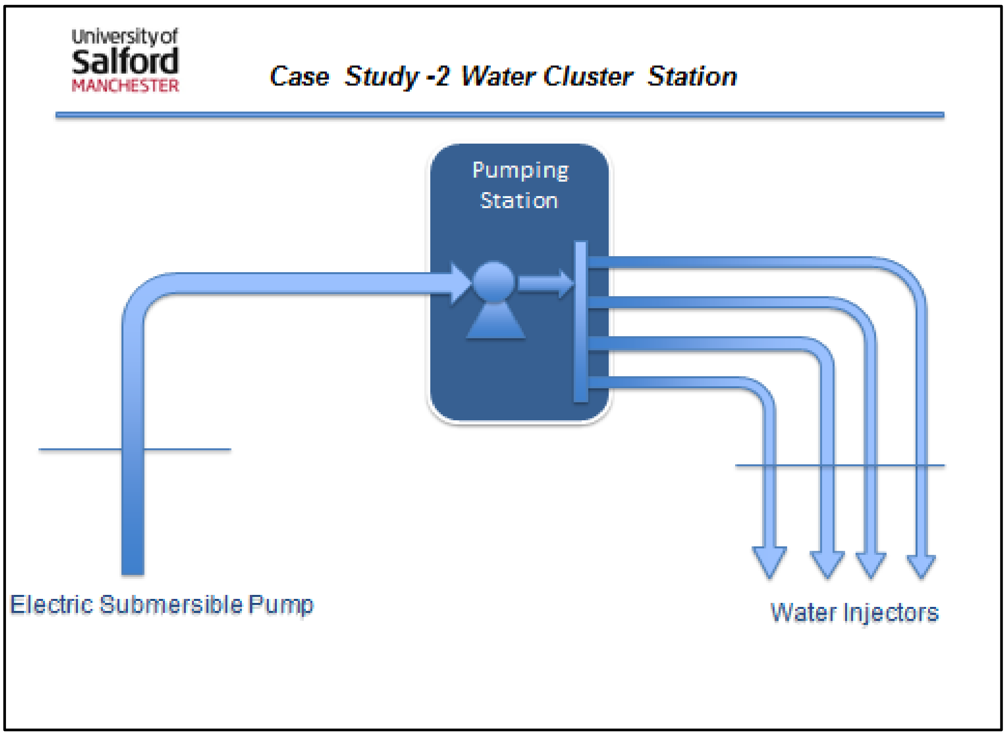


Figure (5.25) Case Study-2 Water Cluster Station

The project execution strategy was conventional; the project started with a normal stage of Select (Concept), Define Stage (Front End Engineering Design- FEED) and Execute stage (Engineering, Procurement and Construction- EPC).

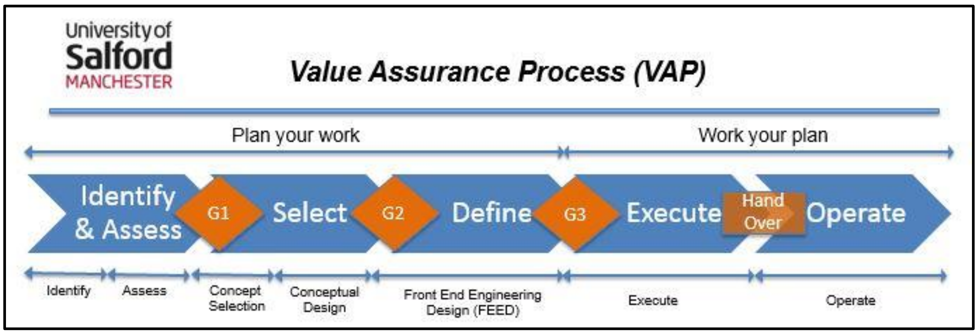


Figure (5.26) Value Assurance Process
Source: ADNOC Value Assurance Book

The mentioned Concept stage was awarded to an international consultant. This consultant was well known for handling this type of high level study. The objective of Concept study was to identify the option available to debottleneck the existing facilities and to fast-track the water injection scheme. The duration of the concept stage was six months where consultants also developed the Term of Reference to bid for the FEED. After the stage gate for concept select is completed, the project moves to the next stage FEED. Using bidding award strategy, the project progresses into the further engineering stage to define all of the engineering deliverables, such as design basis, standardisation, specification, block diagrams, operation philosophies; etc. This stage is called Front End Engineering Design (FEED). FEED was executed by a consultant firm; however, in terms of scale of engineering design, much more resources are mobilised consuming proportionate man-hours. The duration of FEED was nine months. The Define stage (in this context; FEED) ensured that all the required engineering deliverables are detailed sufficiently to secure a competitive Techno-Commercial Bid from EPC Contractors with limited possibility of variations in future. The Execution stage is called EPC, where competent execution contractors are chosen through Techno-commercial bidding & evaluation process, executed the project through detailed phases of Engineering, Procurement & Construction. This stage was completed within 24 months.

This project involved some procurement activities for static, pipelines, flowlines & rotating equipment to handle hydrocarbons. New overhead lines were also constructed to provide additional power. There are some of the commodities in this project to give an idea on the volume of the works: civil (concrete): approx. 100,391 m3, steel structure: approx. 5856 tons, mechanical: approx. 1250 tons, piping: approx. 15,626 id, ohl towers: about 505 nos, electrical & instrument cables: 1166 km. of the estimated 20 million man-hours (approximate) was completed without Lost Time Injury (LTI).

5.4.2 Project Schedule

The Project Concept stage was completed in four months, FEED in nine months, EPC in 13 (due to competitive bidding & Gate approvals) and the EPC is scheduled to be completed in 24 months.

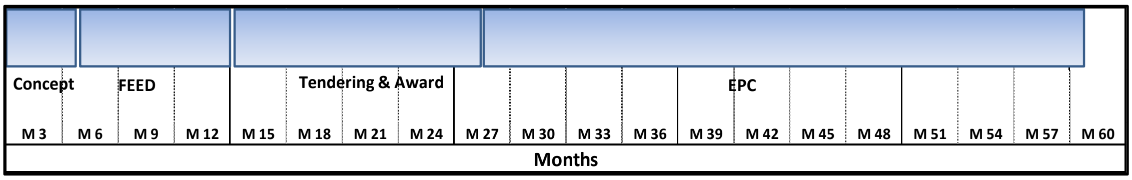


Figure (5.27) Case Study-2 Project Schedule Timeline

5.4.3 Cost

The overall budget of the project was close to 400 Million USD.

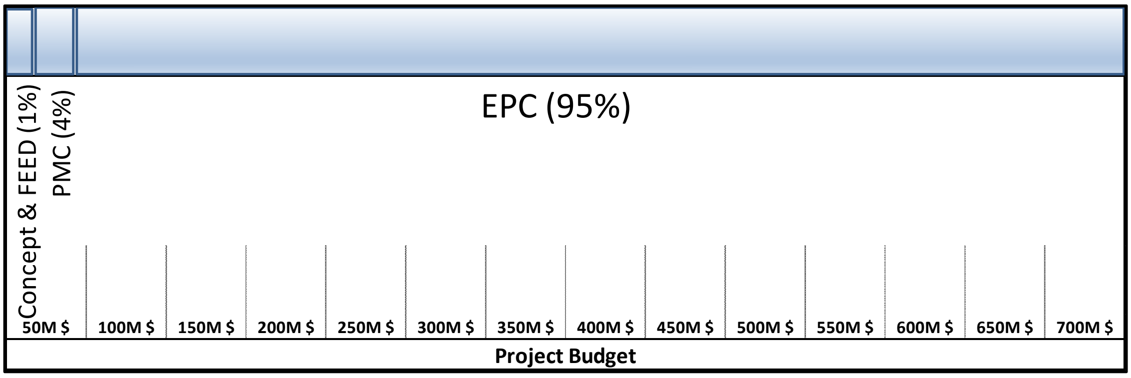


Figure (5.28) Case Study-2 Project Cost Distribution

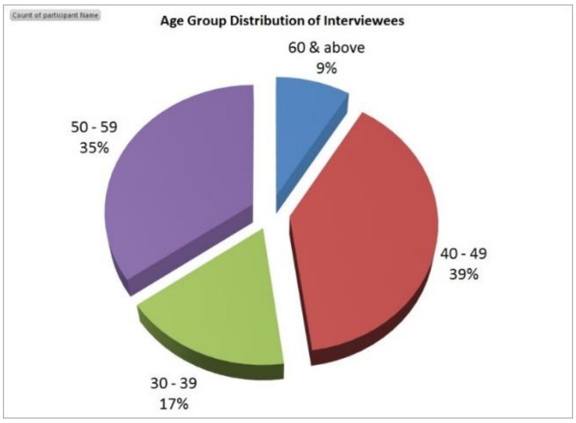
5.4.4 Key Project Problems (Project Poor Performance Factors)

The project was also executed with the typical Oil & Gas design-bid-build strategy, where a communication gap between stakeholders was realised and no formal integration was developed during various project phases. The manufacturer's design changes led to major variations, due to market material supply peak and the poor communication from the FEED side and lack of market peak understanding various variations were raised by the contractor. Poor data collection and limited site survey during the FEED allowed the contractor to request various changes and faced execution difficulties. Operation integration also contributed to the delay and poor performance, since operation absent during 3D design workshops and their requirements were not included to have difficulties to receive the project handover and operate the plant at the required schedule. Strong client management versus poor contractor management skill led to severe gap and clarity in the understanding and implementation; this led to various factors which were behind the project poor performance. These factors were similar to the first case factors but more specific such as in clear design by the FEED consultant, incomplete drawings and clone produced drawings from old projects, conflicts between the drawing and specifications, where the FEED used old specifications and poor review was carried out by the client project team.

Design Changes was one of the factors where the owner made several requests to variate from the scope of work and added and deleted scopes which have impacted the schedule and project cost. The owner set improper construction milestones, where many activities were to be completed earlier than was realistic. A lack of integration of skills at an early stage of planning & design was noticed alongside the poor skills and inexperience of the contractor planning team and the wrong time and cost estimates that were made. Materials were changed in types and specifications during construction to meet the schedule and to reduce the cost without obtaining the owner approval, which were rejected at site and reordered again. Poor qualification of consultant engineer's staff assigned to the project during the design phase led to poor designing documents and incomplete data sheets, which allowed the contractor to procure low quality systems. In various systems, overdesign was observed by the construction contractor during the detailed engineering work and the contractor tried to reduce the sizes and make changes to the design document with significant resistance by the owner. Frequent changes in project staff was one of the problems in this project since the staff continuity affected the progress and the new staff were not familiar with the project history and events. The FEED consultant also used improper Codes for the design, where old standards were mentioned in the documents and the owner requested a new revision be applied. Unrealistic client initial requirements were also an issue since the contractor refused to execute some of the work due to an unclear scope of work and there being no exact instructions. Another problem was waiting for information from the owner during the design phase and data collections. During the construction phase, the government introduced new security measures to control site accessibility; this introduced new checkpoints which impacted the contractors' daily motions and caused daily delays and led to schedule delays. This situation ended up with a claim case from the contractors.

5.4.5 Interviewees’ Status and Background/Involvement

Similar to the first case study, selected stakeholders were encouraged to participate and be interviewed. Below are some of the facts about the interviewees:



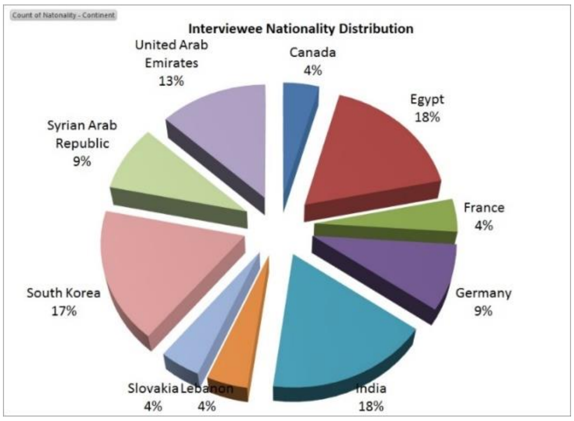
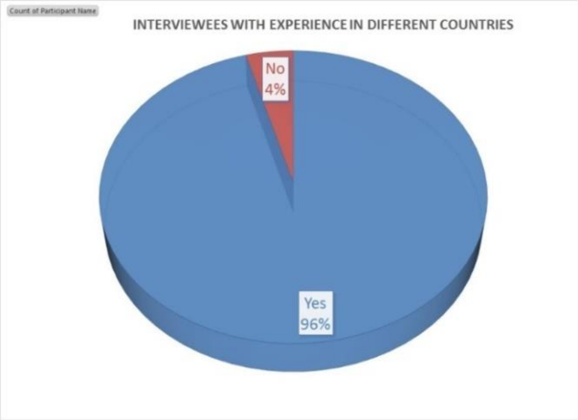


Figure (5.29) Average Age & Nationality Distribution of Interviewees

Again it can be observed that 39% of the interviewees are of an average age between 40–49, 35% of the interviewees are in the range 50–59 and 9% of the interviewees were above 60 years of age. This indicates that the level of experience was high and that the interview participants have various ranges of experience and knowledge. Their age also indicated the intensive experience in the projects.

On the other hand, interviewees’ nationalities were distributed to cover USA/Canada, Europe, Middle East and Far East with Asia. This presented the mixture of interviewees’ culture and social background, which emphasised the project’s global reference and participation.



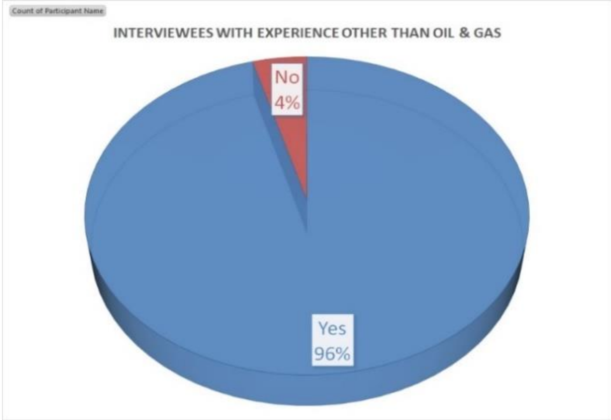


Figure (5.30) Interviewees experience in different countries and industries other than Oil & Gas

As shown in Figure (7.28) above, the majority of the interviewees (about 96%) have experience in more than one country and continent; this will answer whether the factors are related to a specific region or country or these projects are global in nature and similar in various countries. Also it can be observed that 96% of the interviewees have experience in industries other than Oil & Gas such as infrastructure and power projects. This will answer the question whether the factors and framework are only related to Oil and Gas or can be presented to other industries.

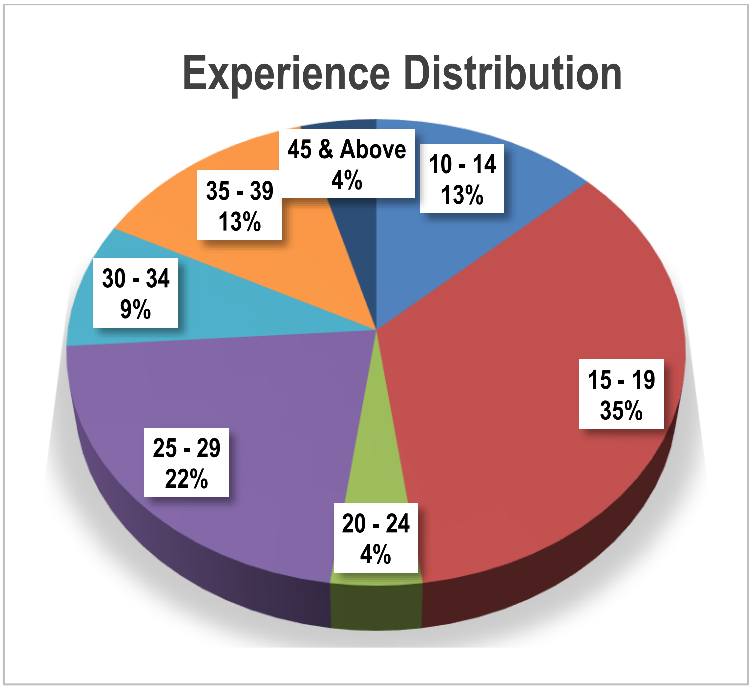


Figure (5.31) Experience Distribution of Interviewees

There is a wide range of overall work experience of the interviewees as shown in the figure above. It was noticed that the interviewees represented wide range of experiences; they came from different backgrounds and countries, worked in various countries and worked also in various industries other than Oil & Gas. This information assisted to understand and answer several general questions such as are the factors related to Oil & Gas industry or could they be present in general construction too; also can the factors and the conceptual framework only be presented in the Middle East and the UAE or could they be presented in regions?

5.4.6 Interviewees Feedback and Analysis

The interview process and sequence of information/sections was kept consistent with all of the interviewees in order to have a typical flow of questions where the objective and subject of the research was addressed, then following on to the poor performance factors, where they occur, who is the main responsible behind them, do they believe that they can be resolved or not, before moving on to explain the IPD definition, principle and challenges and completing the remaining sections of the interview. The IPD explanation was presented last in order to keep the interviewees unbiased to the framework and IPD, and it was noticed that the interviewees were interested in the IPD approach and interviewees started asking questions and seeking clarifications on the IPD principles, the age of the IPD, where it was initiated, how many projects had been implemented, and many other questions. It was therefore necessary to provide them with more details and request that they defer some of the discussion to the end. The first impression was that the IPD principles were new to all the interviewees and the first time they have heard about it; however, they tried to link it with similar existing approaches in the Oil & Gas industry, such as partnering, joint ventures or EPCM (Engineering, Procurement, Construction and Management) strategies, where the design consultant carries on as project management consultant during the execution.

Also they were interested in asking various questions to understand the IPD in greater detail. During the interviews, the interviewees answered the pre-structured questions at the beginning to bring their memories to various factors. Interviewees started to explain the provided questions in their own understanding and events; some of the interviewees started comparing the factors with what they had encountered in the past, such as poor management skills, which led to decisions being delayed and ultimately major delays. Another example was client frequent changes and not clear requirement, which led to unclear scope where the construction contractor took advantage to deviate from the scope. The questions were answered by all the interviewees; it was again noticed that the first five questions were the most difficult to answer by the interviewees due to their slow understanding of the questions, after which they started to answer each question more smoothly. In the second section, interviewees were taken to answer the questions and helped to fill the forms; it was again noticed that interviewees took time to answer the first group of questions (Project Management). In most of the questions, the answers were confirming the agreement of the presented and identified factors in the literature as being behind the poor performance, and the interviewees started expressing various examples of typical problems that they have encountered during their experience related to the same delay. It was mandatory for the researcher to maintain the interviewees' interest to express their own experienced factors and examples in order to allow them to realise the value of impacts and the need to have a solution. Also the interviewees had taken a longer time to express their own experience with the factors occurrence phases and the factors' responsible stakeholders; in several questions the researcher tried to share some of the examples to bring interviewees to the question meaning and various examples were shared and expressed to indicate that factors related to execution may get appear at the design phase and require very early attention.

The discussion took much longer to answer whether the literature factor could occur in the Design, Tendering or EPC phases, and the discussion took much longer to examine the responsible stakeholders – especially the design FEED consultant responsibility. It was obvious that in later questions, the interviewees took less time and started responding faster to agree/disagree on the literature factors, and the answers started harmonise with regard to the occurrence phases. However, the discussion was continued with regard to the stakeholders who are responsible about the delay factor. The researchers were encouraged to maintain the style and interest of the interviewees to express their experiences as far as the time was granted by interviewees and also to keep their passion to answer and have qualitative answers.

The researcher also tried to express other interviewees' feedback, concerns and experiences with some of the factors during the interviews in order to simplify and share other stakeholders' experiences and problems. This style of active and healthy discussion required longer duration for the first interviewees; however, it provided high quality data and responses, which will certainly improve the quality of the research and analysis.

5.4.7 Second Case Study Results

The second case study was conducted with the inputs from the key role stakeholders representing Client, Project Management Consultant (PMC), Designing consultant (FEED), Major Equipment (ICS) Vendor & Construction Contractor (EPC) and subcontractor in a Gas Gathering and Compression Project executed in the Middle East.

The results were plotted in various graphs in order to validate the Factors (secondary) and their collected impact. Based on the inputs from interviewees, the results were carefully analysed to assess their existence, frequency of occurrence and phases of occurrence, in addition to the similarities and to find out the consistency from the perspective above stakeholders.

The results were analysed, taking into consideration the following factors:

1. The stakeholders who have participated in the interview look at the project and analyse the delays from their perspective. For example, a vendor who has got delayed approvals on his engineering documents will assume that

the delay is because of delayed client approvals, whereas the actual reason may be improper design in the first place.

2. The presented stakeholders were involved in different phases of the project and in some of the cases not in all phases of the project due to the Design – Bid – Build strategy followed in the project. However, only the Client and PMC have the complete project experience cycle through all the phases, therefore the feedback will be based on the participated phase for each interviewee.
3. Natural human instinct to protect one's own interest and organisational interest can influence interviewees' responses; however, the researcher tried to share the factors in a project perspective and this condition could impact the responsible stakeholders on the delay, where consistency will be seen in other questions.
4. The interview being repetitive in the nature of questions with so many inputs could have the possibility of human error while assessing and replying to the questions; however, the researcher tried to ensure that the interviewees are focused and their answers are relevant by opening the discussion and by providing some clarification and suggestions with real projects' examples to ease the answers. With the initial data filtering/cleaning it can be assumed that the margin of error will be minimal.
5. The interviewee's global experiences and their execution of various projects in various countries have provided a global feedback and no major specific regional responses were influencing the feedback.

The following graphs were plotted based on the interviews' results.

1. Factor (Secondary Data) Validation by Individual Interviewee
2. Factor (Secondary Data) Validation by Individual Factor
3. Design Phase Factors (occurrence & resolvable) by individual Interviewees
4. Design Phase Factors (occurrence & Resolvable) by Individual factor

5. Tendering Phase Factors (occurrence & resolvable) by individual Interviewees
6. Tendering Phase Factors (occurrence & Resolvable) by Individual factor
7. EPC Phase Factors (occurrence & resolvable) by individual Interviewees
8. EPC Phase Factors (occurrence & Resolvable Early) by Individual factor
9. Factors resolvable by Early Stakeholder Engagement (by individual Interviewees)
10. Factors resolvable by Early Stakeholder Engagement (by Individual factor)
11. Factors phase of Occurrence (by individual Interviewees)
12. Factors phase of Occurrence (by Individual factor)

5.4.7.1 Factor (Secondary Data) Validation by Individual Interviewee

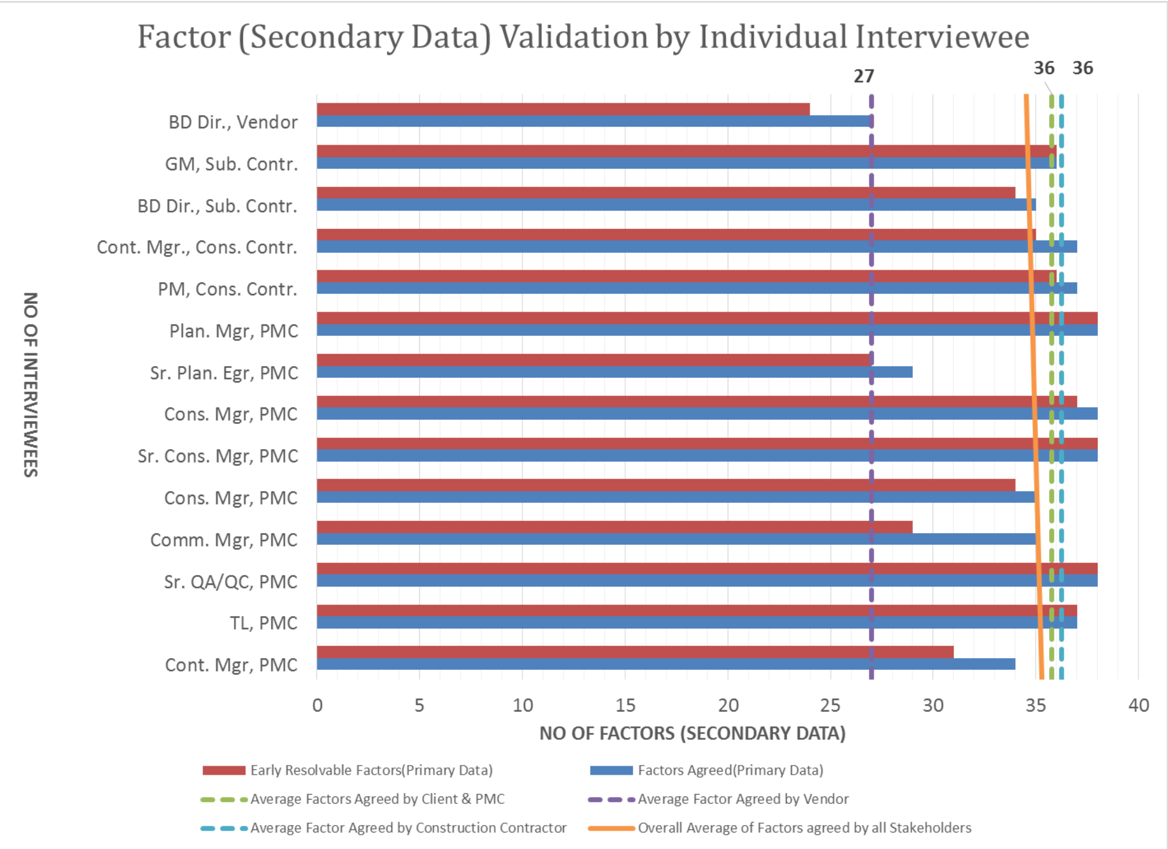


Figure (5.32) Factor (Secondary Data) Validation by Individual Interviewee

The bar chart above shows the factors (secondary data), where interviewees have agreed/confirmed that they are a reason for in project and also agreed whether the factors can be resolved during early design phase. The following observations can be made from the results:

1. On average it can be read that Client & PMC interviewees have an agreement in a large number, i.e. an average of, 95% of the key factors identified from literatures have agreed into (Secondary Data) (Average of 36 out of 38 factors).
2. The client and PMC have also agreed that the majority of these factors are resolvable during early design phase of the project. Some 34 of 38 factors have been voted resolvable by Client & PMC representatives. This again provided solid and genuine feedback from stakeholders who have participated in the entire project cycle (phases).
3. The construction contractor has agreed to 95% of the factors from the literature (Secondary data) (average 36 out of 38 factors).
4. The Vendor has agreed to an average 71% of the factors from literature. The following factors are considered as the factors with no impact on project performance by the vendor:

2. Insufficient team building during design and EPC

5. Project manager does not have full authority

8. Excessive bureaucracy in owner's organisation

11. Lack of IT use in communication and information management

12. Lack of mechanism for recording, analysing, and transferring project lessons learned

15. Inadequate or improper planning from owner to deliver the project

16. Poor estimation of labour productivity by EPC

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

29. Delay in Tendering and award schedule

31. Delay in procurement by contractor

37. Delay in procurement by contractor

5.4.7.2 Factor (Secondary Data) Validation by Individual Factor

This graph above shows the consistency of responses by all stakeholders for the factors identified from Secondary Data Source. The following observations are noted from the above:

1. In general, it can be observed from the above graph that where an interviewee has agreed to a factor which affects the project, the majority have also agreed that it is resolvable early during the project design phase, hence the red & blue lines are seen either overlapping or very close to each other, as highlighted by data point 1.
2. The highlighted data point 2 above show that a lesser number of interviewees have agreed on the factors, but the point to be noted is that almost all who have agreed on the occurrence of the factor have agreed that it can be resolved during early design phase. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

   19. Mega size, design complexity and complications

3. The highlighted data point 3 above shows the anomaly where interviewees have encountered the factor in their past experience but only a few believe it is resolvable during early design. The factors are “Financial issues of Contractor during execution” & “Less time for EPC tendering & too many bidders”.

5.4.7.3 Design Phase Factors (Occurrence & Resolvable) by Individual Interviewees

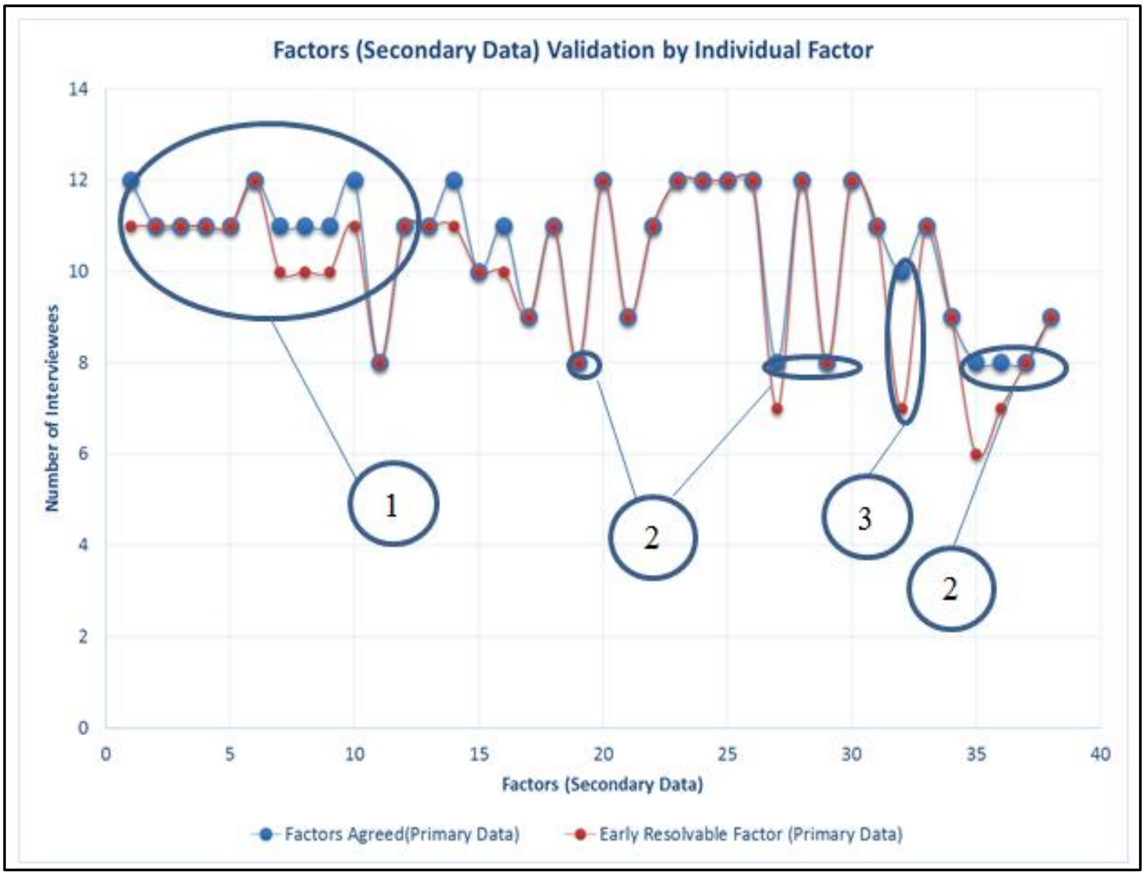


Figure (5.33) Factor (Secondary Data) Validation by Individual Factor

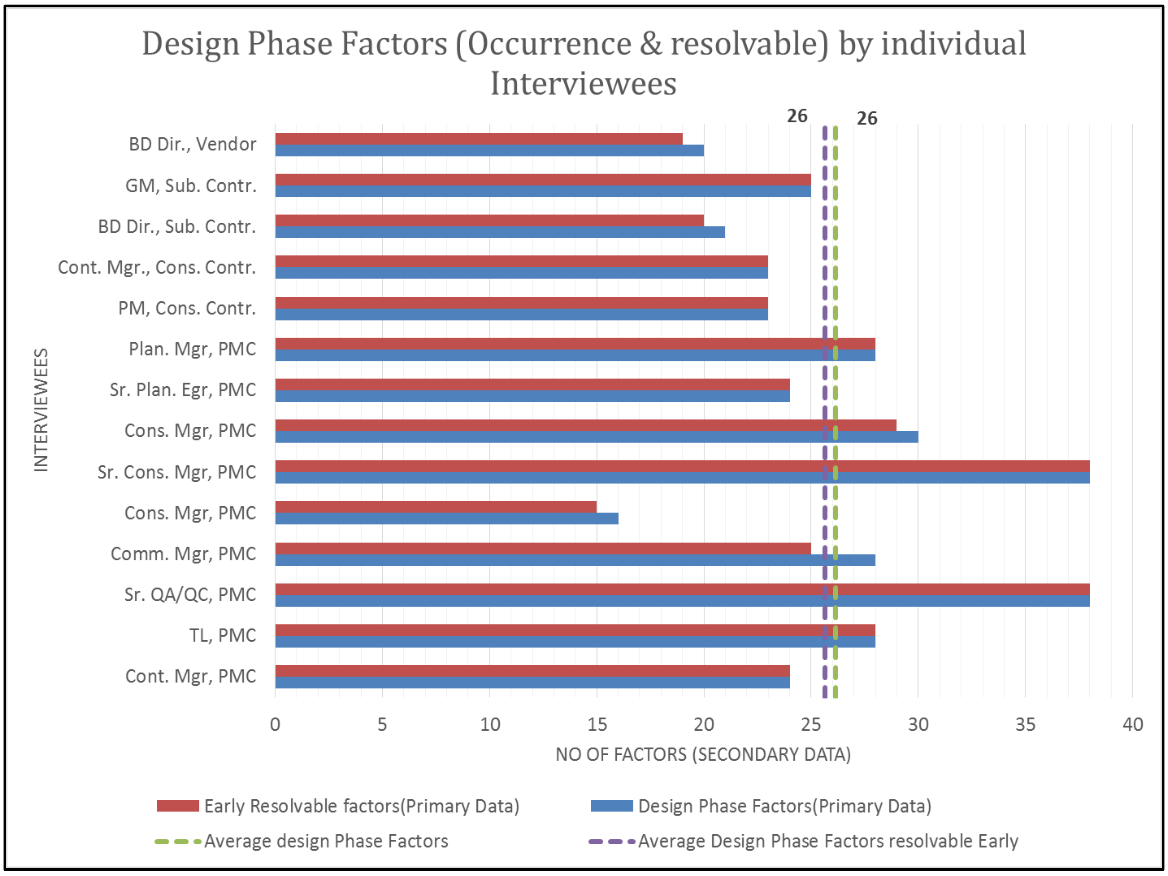


Figure (5.34) Design Phase Factors (occurrence & resolvable) by individual Interviewees

The graph plots interviewees' responses on the number of factors which occurs during the design phase of the project and number of factors that are resolvable during early design phase involvement from the stakeholders. The graph also shows the average number of responses on the factors occurring during the design phase of the project as agreed by interviewees and average number of factors resolvable during early design phase. The following observations can be made from the above:

1. Of the factors agreed to be occurring in the design phase by the interviewees, they also believe that most of these factors can be resolved during early design phase of the project.
2. On average 26 of the 38 factors (68%) are believed to occur in design phase by the interviewees, of which the majority have been agreed to be resolvable early by the interviewees.

5.4.7.4 Design Phase Delay Factors (occurrence & Resolvable) by Individual Delay factor

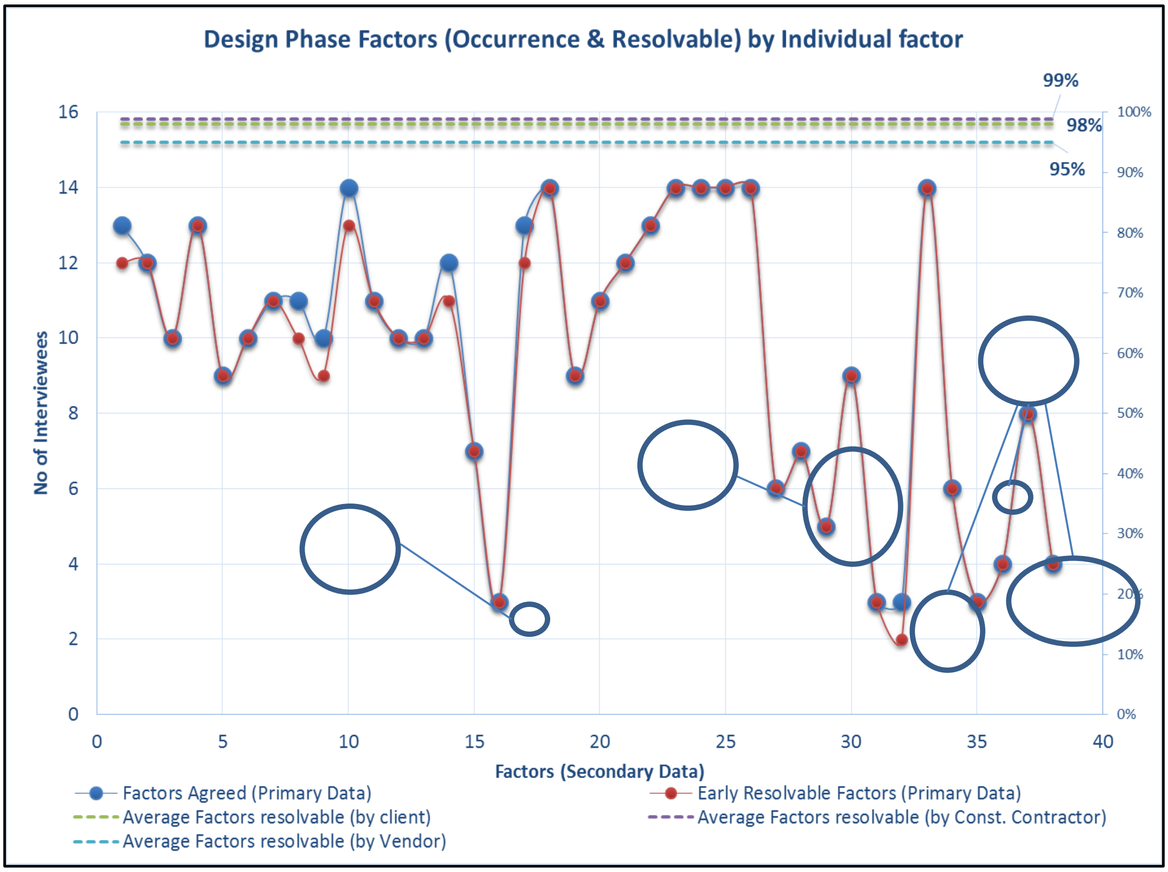


Figure (5.35) Design Phase Delay Factors (occurrence & Resolvable) by Individual Delay factor

The graph shows how many of the interviewees have agreed that each factor occurring in the design phase of a project is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewees' group (Client/PMC, Vendor & Construction Contractor) average on the number of factors resolvable during the early design phase from the ones agreed to be occurring in design phase of the project. The following can be inferred from the graph.

1. On average, it can be observed that almost all of the interviewees have responded with confirmation that all the agreed factors occurring during design phase can be resolved during early design phase.

2. As highlighted in the data point 1, some of the factors have been considered to occur less frequently during the design phase by interviewees. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

16. Poor estimation of labour productivity by EPC
27. Outdated design software
28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding
29. Delay in Tendering and award schedule
31. Delay in procurement by contractor
32. Financial issues of contractor during execution
34. Flexibility of client to adopt technical changes
35. Less time for EPC tendering & too many bidders
36. Limited capability of contractor
38. Poor technical decision during tendering by PMC

5.7.4.5 Tendering Phase Factors (Occurrence & Resolvable) by Individual Interviewees

The graph below plots interviewees' responses on the number of factors which occur during the Tendering phase of the project and the number of these factors that are resolvable during the early design phase. The graph also shows the average number of responses on the factors occurring during the tendering phase as agreed by Interviewees and the average number of factors resolvable during the early design phase.

1. Of the factors agreed to be occurring in the Tendering phase by the interviewees, the interviewees believe that most of the factors can be resolved during the early design phase of the project.
2. On average, 20 of the 38 factors (53%) are believed to occur in the Tendering phase by the interviewees, of which the majority are believed to be resolvable early by the interviewees.
3. It was noticed that interviewees believe that although tendering has an impact on the project delay due to short tendering duration and time

limitation; however, interviewees believe that the tendering phase has less of an impact compared to the design and construction phases.

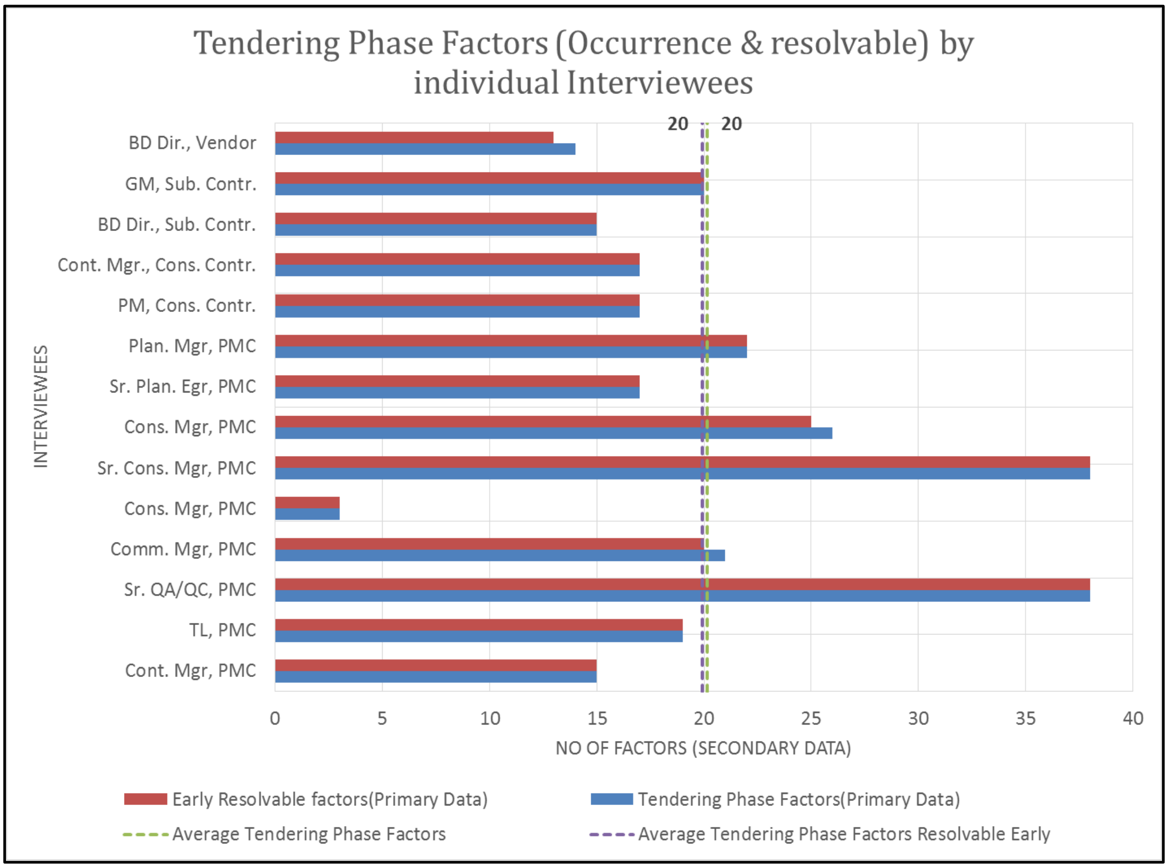


Figure (5.36) Tendering Phase Factors (occurrence & resolvable) by individual Interviewees

5.4.7.6 Tendering Phase Delay Factors (occurrence & Resolvable) by Individual Delay factor

This graph shows how many of the interviewees have agreed that each factor occurring in the tendering phase of a project is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewee group (Client/PMC, Vendor & Construction Contractor) average on the number of factors resolvable during early design phase from the ones agreed to be occurring in Tendering phase of the project.

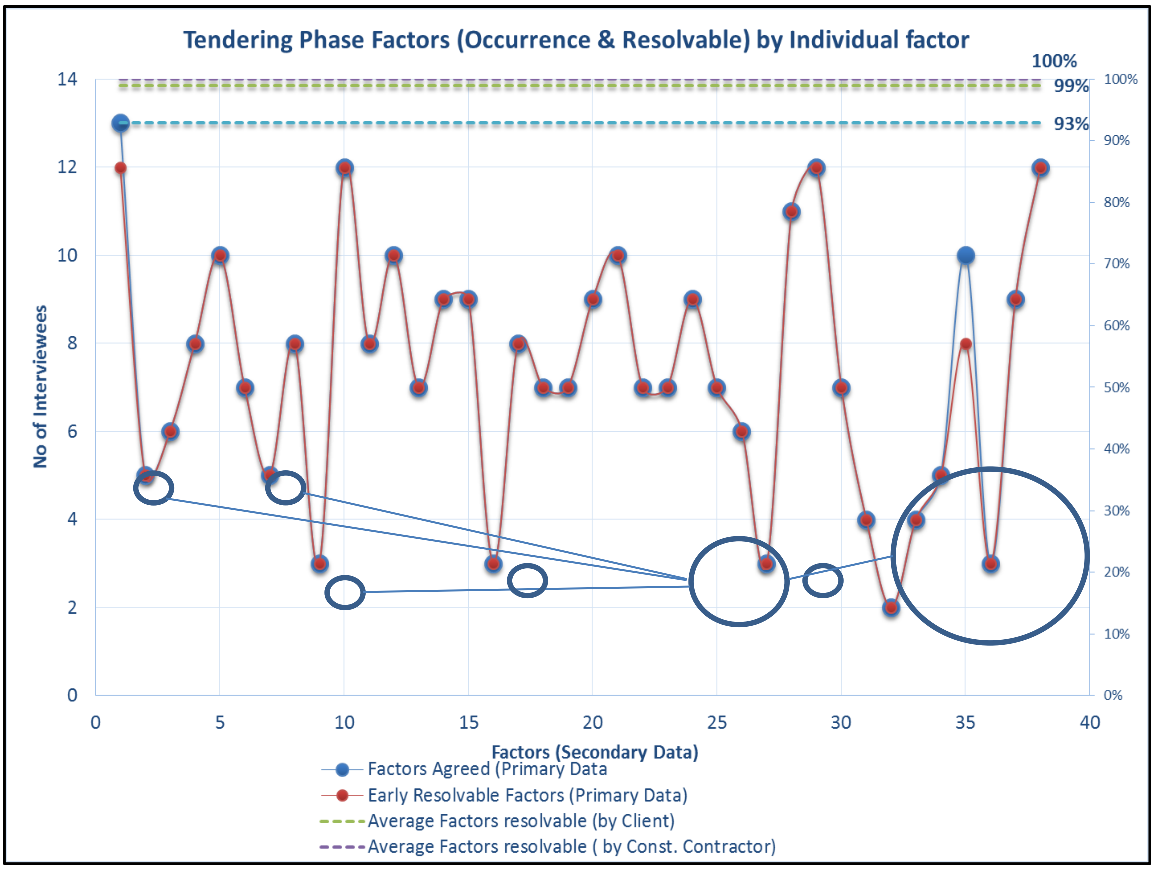


Figure (5.37) Tendering Phase Delay Factors (occurrence & Resolvable) by Individual Delay factor

1. On average, it can be observed that almost all of the interviewees have responded that of the agreed factors occurring during Tendering phase, almost all of them can be resolved during early design phase.
2. The majority of the interviewees have stated that these factors, as highlighted in the data point-1 above, do not occur in the Tendering phase. Below are the factors which fall under this category (point numbers represent the survey questions numbering):

2. Insufficient team building during design and EPC
7. Frequent owner interference
9. Issues regarding permissions/ approvals from other stakeholders
16. Poor estimation of labour productivity by EPC
19. Mega size, design complexity and complications
27. Outdated design software
31. Delay in procurement by contractor

32. Financial issues of contractor during execution
33. Delay in mobilization during design & EPC
34. Flexibility of client to adopt technical changes
36. Limited capability of contractor

5.4.7.7 EPC Phase Factors (Occurrence & Resolvable) by Individual Interviewees

This graph plots interviewee' responses on the number of factors which occur during the Construction (EPC) phase of the project and the number of factors that are resolvable during the early design phase if they are addressed properly. The graph also shows the average number of responses on the factors occurring during the EPC phase as agreed by interviewees and the average number of factors resolvable during the early design phase.

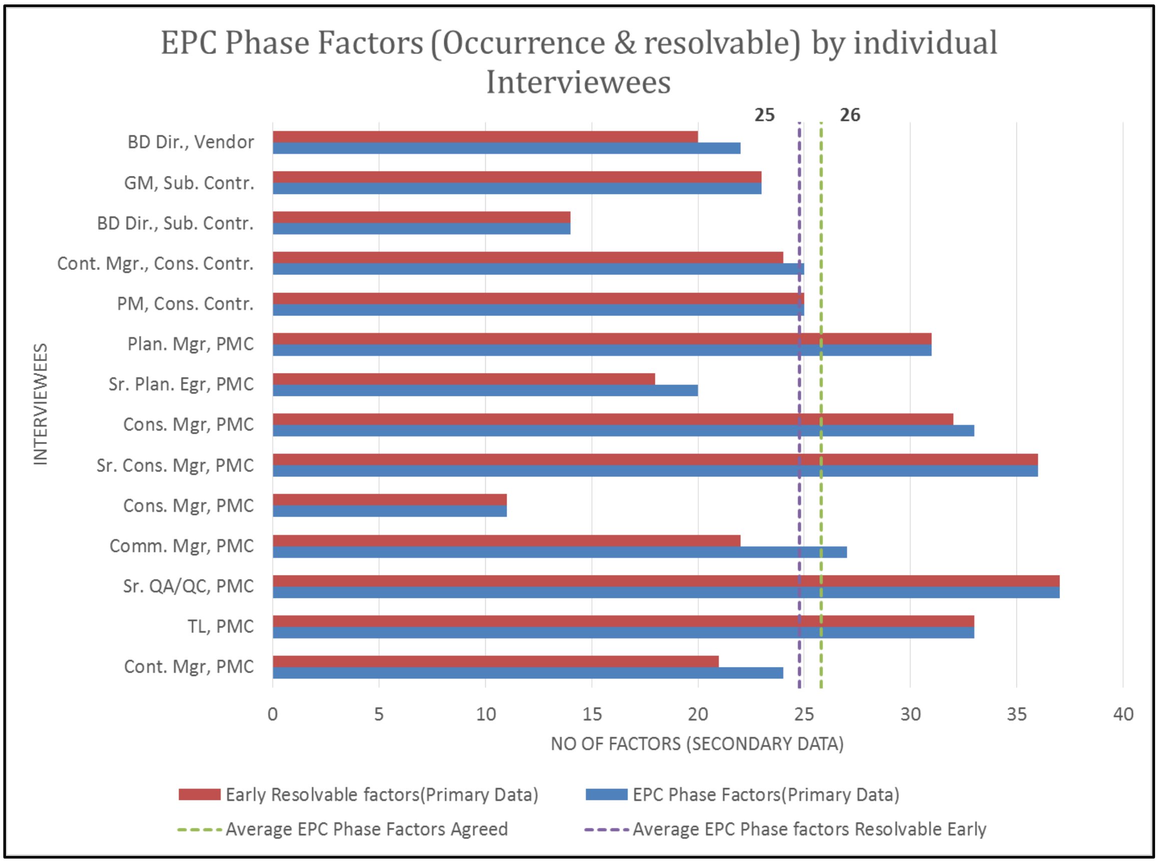


Figure (5.38) EPC Phase Factors (occurrence & resolvable) by individual Interviewees

The following observations were made from the above graph:

1. Of the factors agreed to be occurring in the EPC phase, almost all of the stakeholders believe that most of the factors can be resolved during early design phase of the project.
2. On average 26 of the 38 factors (68%) are believed to occur in EPC phase by the interviewees, of which the majority have been agreed to be resolvable early by the interviewees.

5.4.7.8 EPC Phase Delay Factors (Occurrence & Resolvable Early) by Individual Delay Factor:

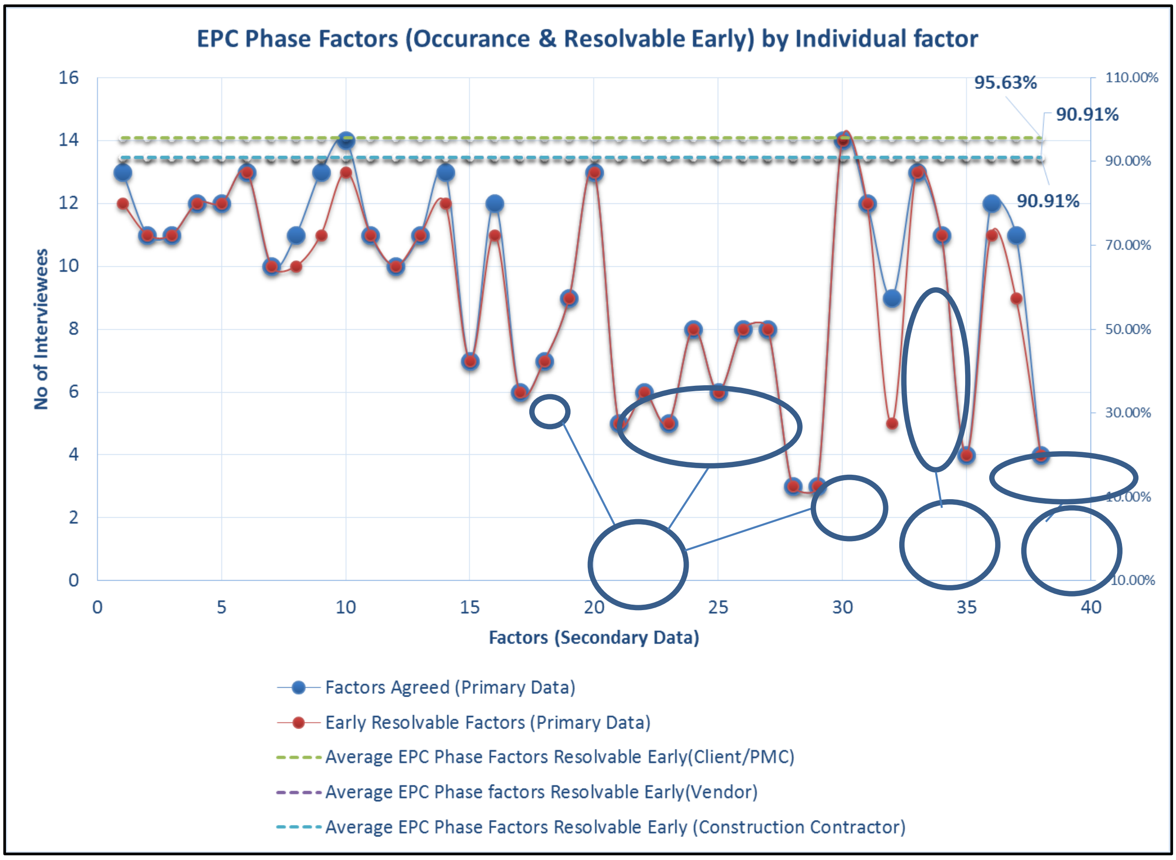


Figure (5.39) EPC Phase Delay Factors (occurrence & Resolvable Early) by Individual Delay factor

This graph shows how many of the interviewees have agreed that each factor occurring in the EPC phase of a project is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewee group (client/PMC, vendor & construction contractor) average on the number of factors resolvable during early design phase from the ones agreed to be occurring in EPC phase of the project. The observations from the above graph is listed below:

1. In general, it can be noticed that out of the agreed number of factors by the stakeholder groups, an average of 98% factors is considered as resolvable early by construction contractor, 96% of factors is considered resolvable early by the client and 90% of the factors resolvable early by the vendor. The maximum anomaly can be found in the case of the vendor where factors are considered not resolvable early.
2. As highlighted in the data point 1 above, the majority of the interviewees have considered these factors to occur during the EPC phase by a smaller number of interviewees. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

21. Inadequate project objective and scope definition by owner and FEED designer

22. Lack of engineering clear roles/goals

23. Poor quality of deliverables by FEED designer

25. Lack of Communication between FEED engineers and other stakeholders (operation & maintenance)

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in Tendering and award schedule

35. Less time for EPC tendering & too many bidders

38. Poor technical decision during tendering by PMC

3. Data point 2 highlights the factor which believed to occur during EPC by many interviewees, although a comparatively lower number of interviewees have agreed that it is resolvable during the early design phase of the project. The factor highlighted is:

32. Financial issues of contractor during execution

5.4.7.9 Factors Resolvable by Early Stakeholder Engagement (by Individual Interviewees):

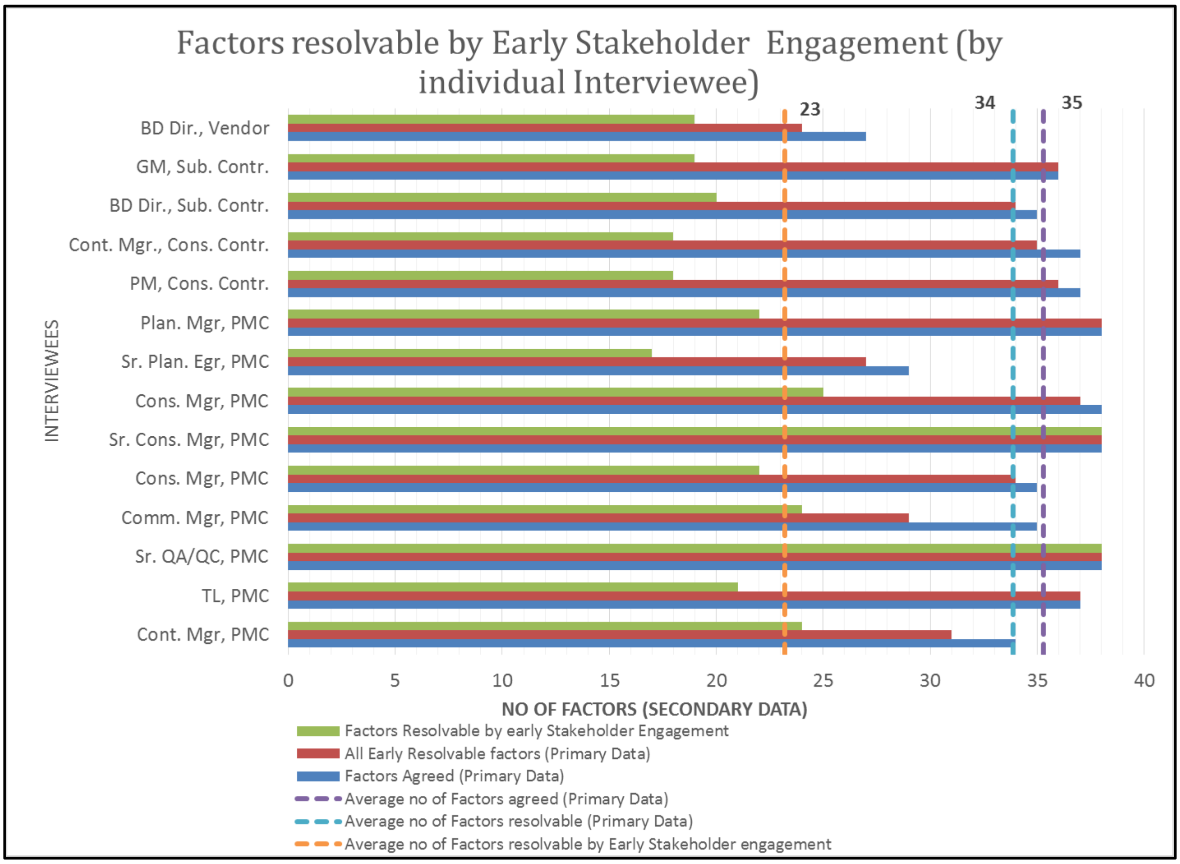


Figure (5.40) Factors resolvable by Early Stakeholder Engagement (by individual Interviewees)

This graph plots the individual interviewee response on the number of factors from the secondary data which occur during the project, the number of factors resolvable during early design phase and the number of factors which require early engagement of stakeholders for resolving the factors who generally get involved in the later stages of project viz. construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors. The following observations can be made from the above graph:

4. About an average of 65% of the factors agreed by interviewees, can be resolved by early engagement of late stakeholders during the early design phase. These stakeholders are generally identified and involved usually at

later stages of the project viz. construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors.

5. About 24% of the factors can be resolved during the early design phase without any early engagement of construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors.
6. An overall average of 97% of the factors selected from Secondary data can be resolved during the early design phase.

5.4.7.10 Factors Resolvable by Early Stakeholder Engagement (by Individual Delay factor):

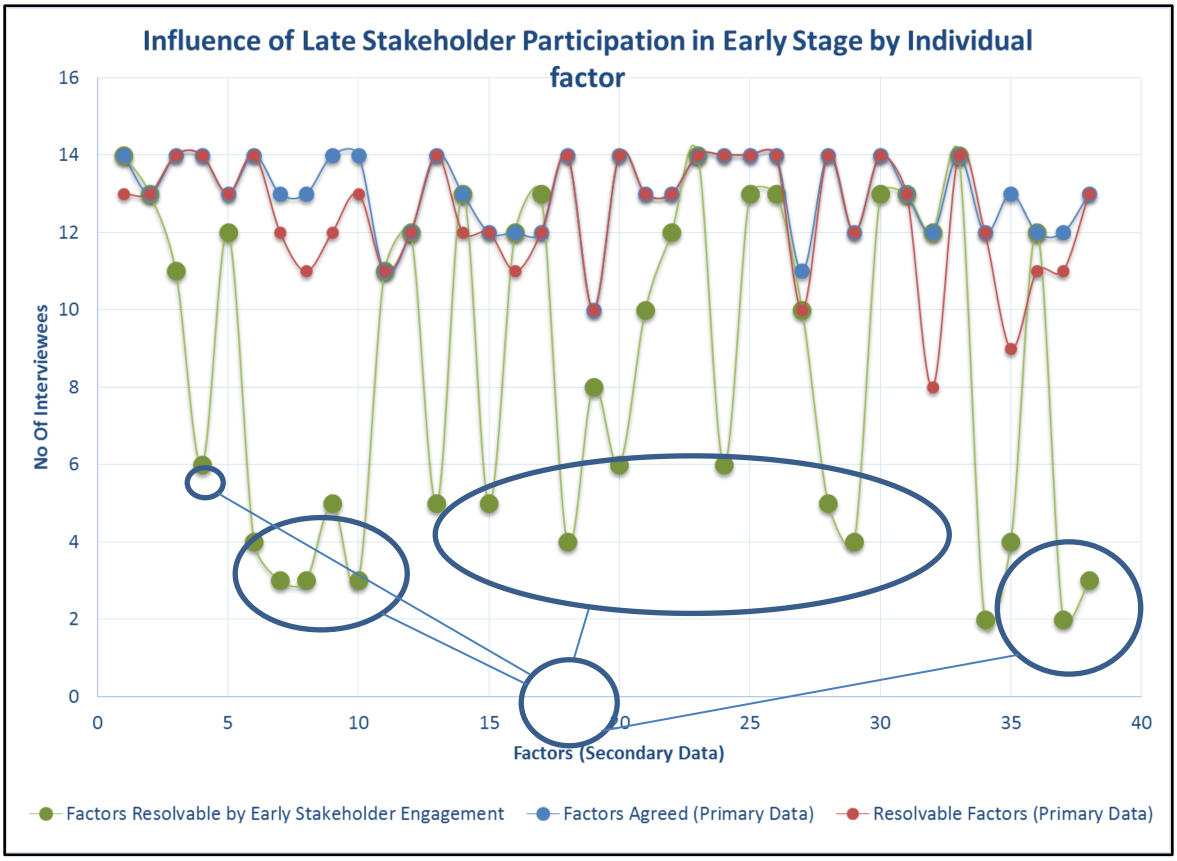


Figure (5.41) Factors resolvable by Early Stakeholder Engagement (by Individual Delay factor)

This graph shows how many of the Interviewees have agreed that each factor occurring in the Construction (EPC) phase of a project is a reason for project delay, how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project, and how many interviewees have agreed that each of the factors require early engagement of stakeholders for resolving the factors, who generally get involved in the later stages of project viz. construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors.

1. From the data points 1 selected above, it can be seen that a number of factors (approximately 42%) can be resolved without early engagement of construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors, even though early engagement of these stakeholders can improve the quality and schedule. The following are the factors which fall under this category, (point numbers represent the survey questions numbering):

4. Conflicts/disputes between owner stakeholders (project team and operations)

6. Insufficient and inexperienced management personnel from owner

7. Frequent owner interference

8. Excessive bureaucracy in owner's organisation

9. Issues regarding permissions/ approvals from other stakeholders

10. Slow decision-making & lack of staff involvement from owner side

13. Inadequate control procedures from owner side to monitor the progress and delay

15. Inadequate or improper planning from owner to deliver the project

18. Lack of client participation in major milestones during design

20. Design variations or changes in client requirement

24. Delayed or insufficient design information from owner

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in tendering and award schedule

34. Flexibility of client to adopt technical changes

35. Less time for EPC tendering and too many bidders

37. Limited authority of PMC consultant

38. Poor technical decision during tendering by PMC.

5.4.7.11 Factors Phase of Occurrence (by Individual Interviewees):

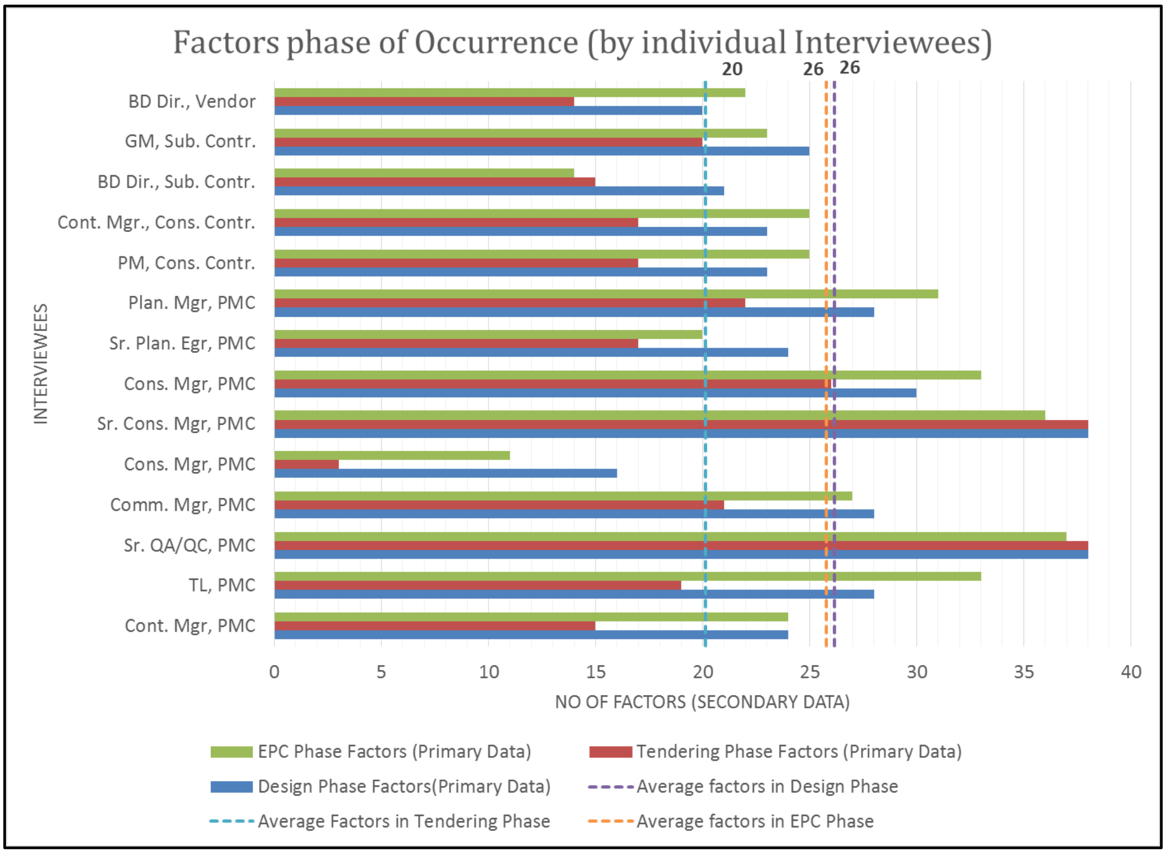


Figure (5.42) Factors phase of Occurrence (by individual Interviewees)

This graph shows by individual interviewee's feedback how many factors occur in each phase of the project.

1. Based on the interviewee feedback, about 64% of the delays occur during the design phase of the project, 50% occur during Tendering Phase of the project & 72% occur during EPC phase.
2. All groups of interviewees (Client/PMC, Vendor & Construction Contractor) have agreed that on average, the highest number of factors (selected from secondary data) occur during EPC followed by Design, and the lowest number of factors occur during Tendering.

5.4.7.12 Factors Phase of Occurrence (by Individual Delay Factor):

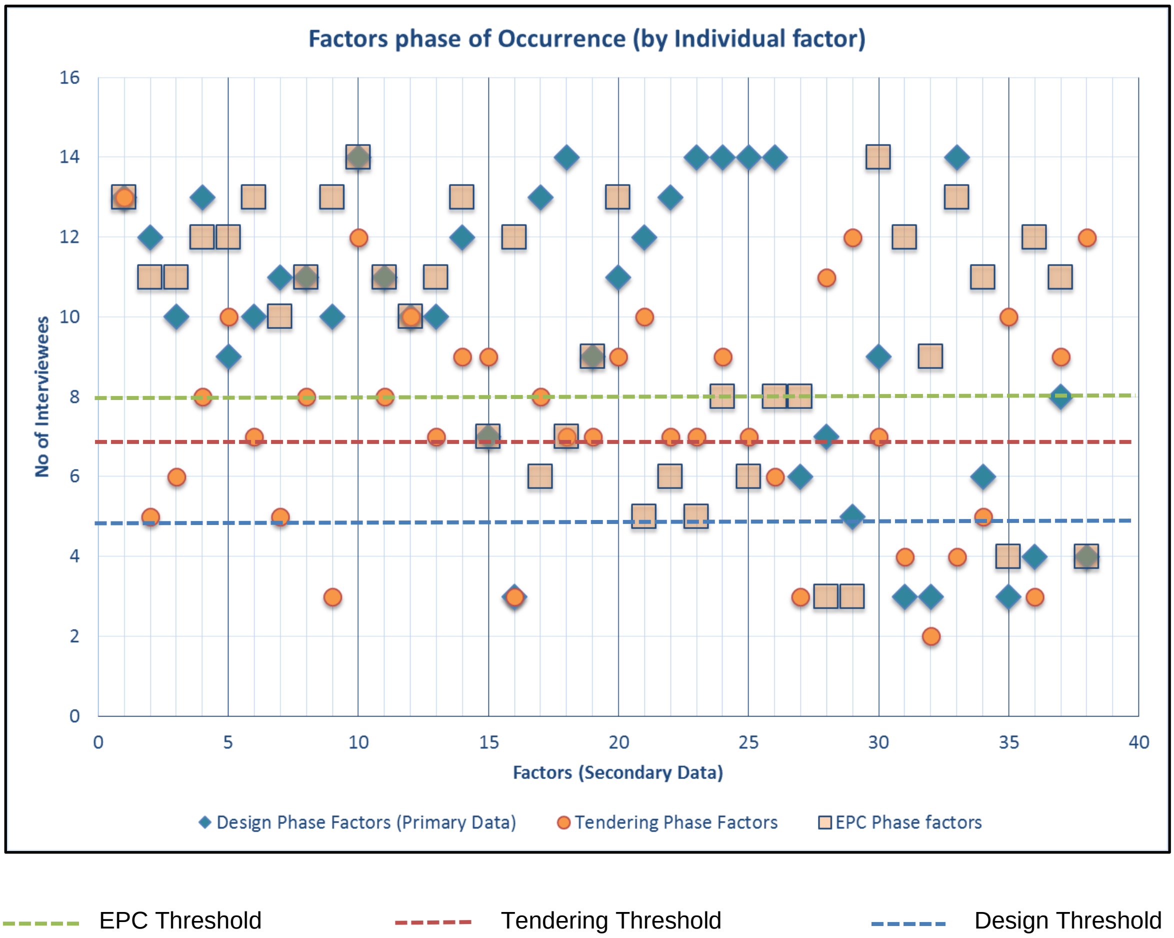


Figure (5.43) Factors phase of Occurrence (by Individual Delay factor)

This graph shows by individual factor how many interviewees have voted that a factor can occur in each of the phases of the project viz., Design, Tendering & EPC.

1. From the graph above, it can be observed that very few interviewees have voted for some of the factors which occur in the phases covered by the highlighted region in the graph above. The researcher, after referring to each mentioned factor, realised that interviewees' answers are relevant and that these factors are irrelevant to the phase of the project. Some of the examples for factors not expected to occur under each of the phases are listed below:
2. Factors not expected to occur during Design, (point numbers represent the survey questions numbering):

29. Delay in Tendering and award schedule

31. Delay in procurement by contractor

32. Financial issues of contractor during execution

35. Less time for EPC tendering & too many bidders

36. Limited capability of contractor

38. Poor technical decision during tendering by PMC

3. Factors not expected to occur during Tendering, (point numbers represent the survey questions numbering):

2. Insufficient team building during design and EPC.

3. Inappropriate overall organisation structure linking all project teams

6. Insufficient and inexperienced management personnel from owner

7. Frequent owner interference

9. Issues regarding permissions/approvals from other stakeholders

13. Inadequate control procedures from owner side to monitor the progress and delay

16. Poor estimation of labour productivity by EPC

18. Lack of client participation in major milestones during design

19. Mega size, design complexity and complications

22. Lack of engineering clear roles/goals

23. Poor quality of deliverables by FEED designer

25. Lack of Communication between FEED engineers and other stakeholders (operation & maintenance)

26. Lack of communication between FEED engineers and other stakeholders (operation & maintenance)

27. Outdated design Software

30. Inadequate contractor experience - all phases, unfamiliar with regulations, policies and local law changes or issues and lack of knowledge in social &cultural factors

31. Delay in procurement by contractor

32. Financial issues of contractor during execution

33. Delay in mobilization during Design & EPC

34. Flexibility of client to adopt technical changes

36. Limited capability of contractor

4. Factors not expected to occur during EPC, (point numbers represent the survey questions numbering)

15. Inadequate or improper planning from owner to deliver the project

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

18. Lack of client participation in major milestones during design

21. Inadequate project objective and scope definition by owner and FEED designer

22. Lack of engineering clear roles/goals

23. Poor quality of deliverables by FEED designer

24. Delayed or insufficient design information from owner

25. Lack of communication between FEED engineers and other stakeholders (operation & maintenance)

26. Inconsistency between specification, prevailing international standards and owner's procedures/specifications.

27. Outdated design software

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in Tendering and award schedule

35. Less time for EPC tendering and too many bidders

38. Poor technical decision during tendering by PMC.

5.6 Case Study 3

5.5.1 Project Experience

One of the projects, "Gas Compression station Project" was executed in the Middle East with an objective to support the increasing gas demand on the national grid by adding an additional compression station to boost the gas pressure collected from new gas gathering facilities connected to compressor trains in a new compression station in another location compared to the old compression facilities. The project involved the development of new gas wells connected via existing gathering facilities then a new pipeline connected to a new compression facility with three individual trains of separation and compression and finally delivering compressed gas to a downstream gas processing facility. The process schematic is shown below:

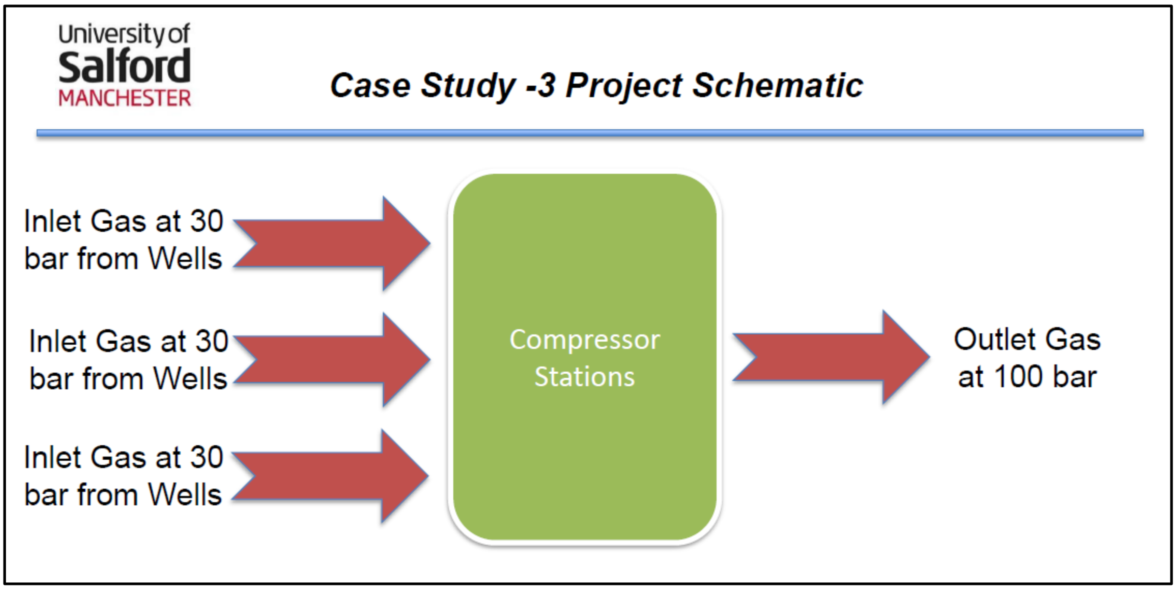


Figure (5.44) Case Study-3 Process Schematic

The project was executed with the implementation of lessons learned from a typical project completed earlier in the same field. Even though the project followed a traditional "Design – Bid – Build" project delivery method, lessons learned from the EPC contractor of the earlier executed similar project helped in the mitigation of "high impact" risks that the operation involved in the project and fully familiar with the existing problems and lessons made positive feedback and design. The project was executed with the stage-gate philosophy with gates and approvals after each stage of concept, Front End Engineering Design (FEED) and Execution. More details were captured during FEED, which allowed early ordering of the compressors, which were of the long lead items.

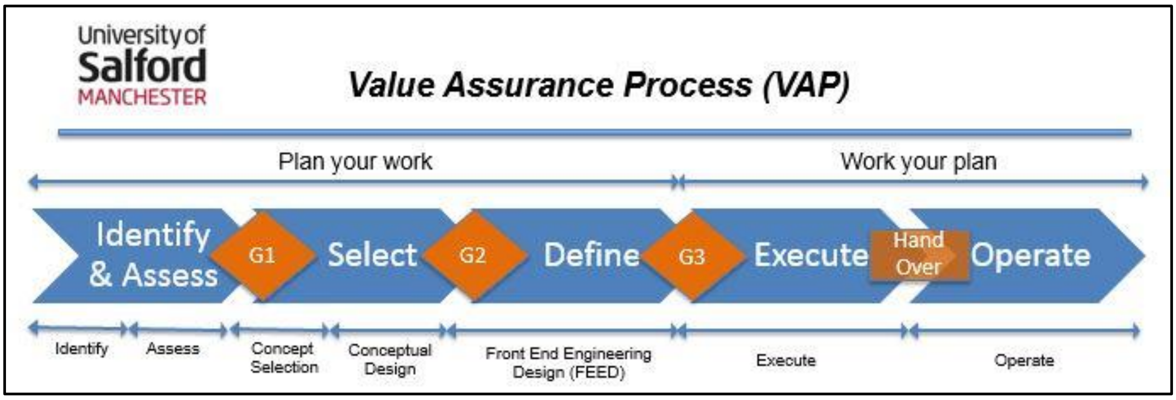


Figure (5.45) Value Assurance Process
Source: ADNOC Value Assurance Book

The concept selection and definition phase was completed by an EPC contractor. The client requested him to develop the same engineering details to build a station similar to one in another location. The client also requested to avoid major changes to the existing design, plot layout and operating philosophy, which should help the operator to maintain the same mind-set. The concept stage basically involved cost & schedule analysis of all available options of developing facilities with proven technologies to achieve the project objective, such as to deliver the project with the least capital and operating expenditure, high reliability and best possible schedule with scope for future expansion with similar objectives. Two major options were studied and evaluated in the concept phase: one is to install an additional compressor in each of the existing station (brown field), or to build up a brand new station with all the compressors (green field).

The concept phase was completed with the option to build a brand new compressor station rather than installing a new compressor in each of the existing station, the concept identified the problems by working under brown field and the existing facility adequacy studies showed there are major shutdowns are required to install new compressor unit in the existing station, also there is production interruption which was rejected by the client. On the other hand, the cost showed that adding compressor compared to building a new station would be more expensive due to major tie-ins to the facilities, safety and increase in the supervision. Therefore, the selection was to go with a green field concept where a new station would be built with minimum interruption to the gas production. This concept was completed within the stipulated six-month period and with the development scenario selected the project was awarded for FEED. The FEED was executed by the same concept consultant and moved ahead to develop the FEED design using the previously produced FEED designs and the available detail engineering documents. The FEED was more exhaustive with implementation of available lessons from various stakeholders such as client, FEED & EPC subcontractors of previously executed project. With a good level of design data available from earlier projects within the design range, process datasheets and specifications were developed for the compressors, which require maximum lead time for delivery from the date of purchase orders. The FEED phase was executed in about eight months with detailed project definition. The project Tender package was prepared during FEED for the EPC bidders to bid for through an open bidding strategy, where all major EPC Contractors were invited to submit their Techno-commercial bids for the project.

Several rounds of Tender clarifications were conducted for the contractors to understand the project scope clearly and the contractors were asked to submit their Techno-commercial offers after the Tender clarification rounds. The bids were evaluated based on several project selection criteria such as schedule, experience, execution strategy, financial health of the contractors, cost, etc. The EPC phase was awarded to the successful EPC contractor. The project was planned with a very detailed structure for schedule and risk management. The project qualified as a large-scale project, which involved development of facilities spread over a wide geographical locations and involving several governmental and third party stake holders. The project was multi-disciplinary in nature involving works such as infrastructure development, process facilities, piping, pipeline, electrical distribution and substations, Telecommunication, structures and static and rotating mechanical equipment, etc. The quantities of commodities were; civil concrete: approx. 300,000 m3, steel structures: approx. 15,000 metric tons, buildings concrete: approx. 25,000 m3, mechanical equipment installation: approx. 23,500 metric tons, piping: approx. 550,000 inch diameter, electrical & instrumentation cables: approx. 10,400 kms and flowlines: approx. 200 kms.

5.5.2 Project Schedule

The concept design and FEED was completed within 12 months; four months for the concept and eight months for the FEED. EPC tendering was done in two phases, totalled 12 months. The design phase of the project was executed from the contractor's home office in the Far East as well as a satellite office in South Asia. The duration of the detailed Engineering phase was around 10 months from the date of award with as built documentation and vendor deliverables continuing for another four to six months. Major equipment procurement orders were placed early within the first six months of EPC award and procurement of bulks continued for another six months. The majority of deliveries were secured by the 24th month from commencement of EPC. The construction phase started with initial infrastructure and civil works with an overlap of three to four months with the last leg of detailed design and continued for 24 months with majority of construction phase overlapping with material deliveries. The final commissioning was completed in another three months after completion of construction.

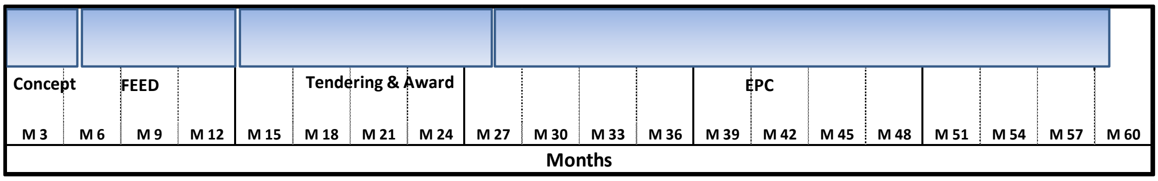


Figure (5.46) Case Study-3 Project Schedule Timeline

5.5.3 Project Cost

The overall budget of the project was close to 700 million USD.

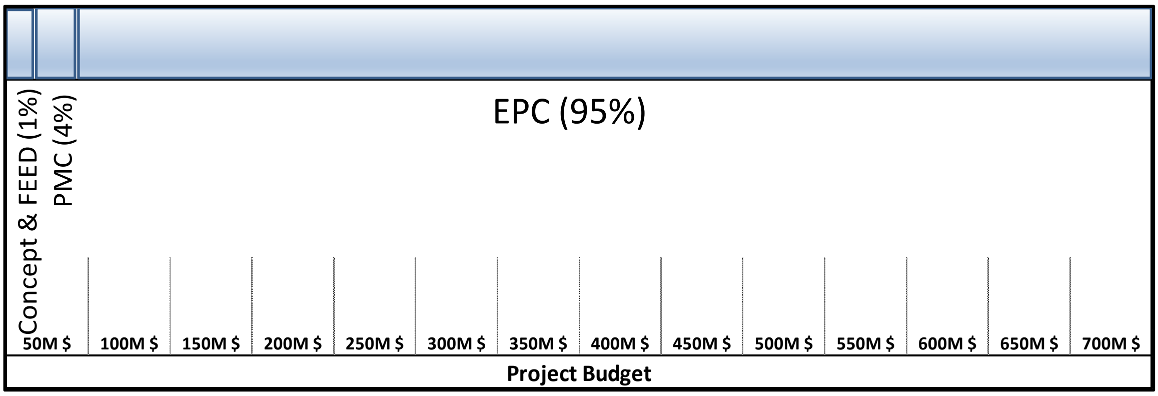


Figure (5.47) Case Study-3 Project Cost Distribution

5.5.4 Key Project Problems (Project Poor Performance Factors)

Since the FEED consultant was the same EPC contractor for the previously built station, the consultant tried to duplicate the previously produced deliverables without proper reviews and the consultant started rejecting client comments since these documents were issued and working in the previous project. Also the FEED consultant tried to use the same details as had been produced in the past. This approach made the other competitive bidders for the EPC spend more time evaluating the proposal. This took longer and the FEED had technical and lessons learnt advantage on the competitors. The FEED for the project was also incomplete with omissions on several technical details. Due to the incomplete FEED, it was noted that during bidding for EPC, the bidders added too many contingencies to the cost of project development. Hence the bidding cycle involved several sessions of technical clarifications and rebidding. The FEED did not incorporate the As-built data of several facilities which were interfacing with the facilities to be designed under the scope of the project. Datasheets and specifications were incomplete which allowed the EPC contractor and vendors to choose from a wide range of technical options during the detailed design. Due to incomplete technical information Material Requisitions had to be revised several times, in some cases orders had to be revised after award.

During detailed design, the EPC contractor conducted a major part of the engineering from a satellite office in South Asia, which impacted the quality of the documents and the document turn-around cycle time. Since the client had shifted its base to the contractor home office, integration and communication issues were recorded on the majority of the work conducted from the satellite office.

The contractor had prepared initial scheduling with several assumptions and insufficient discussion with the contractor’s engineering team. Hence the engineering man-hours were underestimated and lead time for technical clarifications were not considered, which impacted both the design and procurement schedules. The construction schedule prepared between the contractor and his sub-contractors were not integrated and communicated at all levels. Material deliveries were not prioritised on the same priority levels as the construction schedule, hence the construction schedule had to be revised several times during the course of execution. The contractor’s controls team was not experienced and failed to have sufficient information or authority to control the project. Hence several non-priority activities were given higher importance and man-hours. The contractor’s control team was changed several times during execution, this lead to several levels of miscommunications.

Since detailed route surveys were not done during FEED, the EPC contractor had to wait for all governmental approvals for getting work permits and only then could mobilise his survey team. This delayed the survey activities and subsequently the pipeline engineering activities. Interface with work permit authority was not managed properly by EPC Contractor, hence the permit request had to be resubmitted several times before approval. Poor communication was noted from the contractor’s office with no single point responsibility for interfacing between client, third parties, governmental agencies and vendors. This caused delays at the design, procurement and construction stages. Product inspections at vendor works were not planned in advance and underqualified third-party inspectors were engaged, which delayed the inspection cycles at vendor works. Several materials were rejected from the site due to improper inspection at vendor works. The contractor’s main objective was to save cost hence several technical deviations were raised, eventually lead to procurement delays.

Different systems used by the contractor and sub-contractor for monitoring and reporting progress caused different actual construction progress figures. Progress weight factors for payment milestones between client and main contractor was not in line with the pricing schedule between main contractor and sub-contractor hence in order to achieve higher payment the sub-contractor worked on different set of priorities. This lead to greater mismatch between the material deliveries and construction sequence and also several man-power idling was noted during the construction phase.

Higher progress was projected by contractor in progress reports, which lead to major deductions from the invoiced amount. Invoices were not supported with proper backup documents validated by the client, hence the cash flows in the project were not in line with the progress reported.

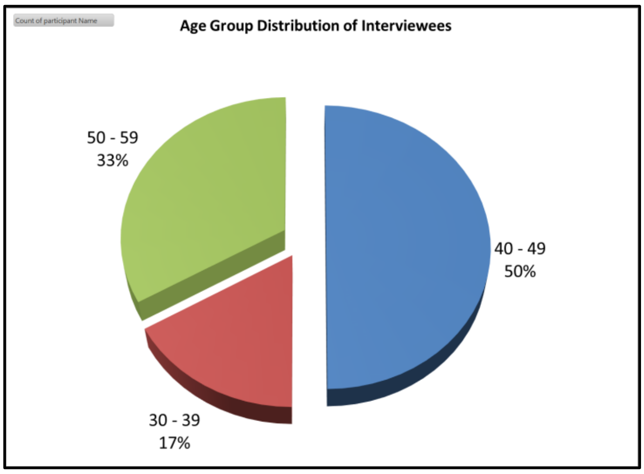
5.5.5 Key Achievements (Performance Improvement Factors)

One of the major achievements during the project was that lessons learned from a similar project completed earlier was incorporated early in the project documentation and was communicated to all bidders during EPC bidding stage. There was measurable improvement in the EPC schedule due to this initiative. The compressors were ordered within six months from award of EPC, which helped with securing the deliveries of these long lead items as per the schedule.

The client formed a very experienced team to manage the project at all levels. This compensated for several inefficiencies in the EPC contractor’s organisation. The client was very participative in decision-making processes, which allowed reducing the documents recycle time. The client ensured majority of operation lessons learnt were included. Always closed the gap of man-power shortages, and avoid the bad reference manufacturers from the previous project.

5.5.6 Interviewees’ Status and Background/Involvement

A wide range of participants were chosen from the project for this case study. The interviewed members had worked in different projects and locations, below some of the facts about the interviewees in the first case study:



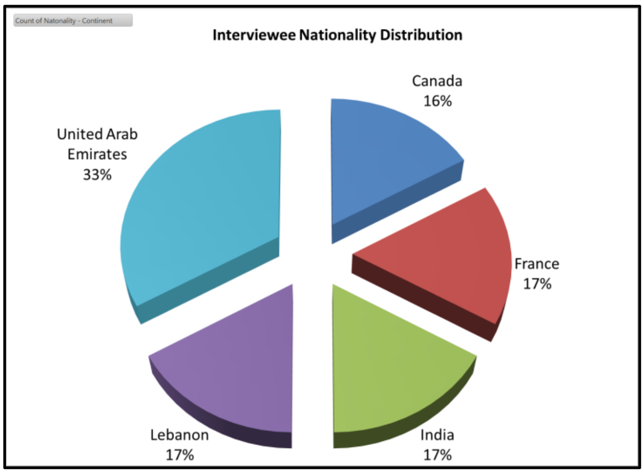
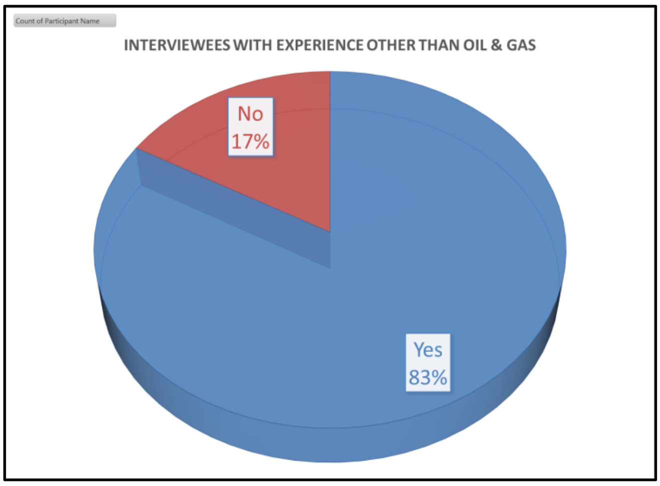


Figure (5.48) Average Age & Nationality Distribution of Interviewees

It can be seen in the above figure that 14% of the interviewees are aged between 30–39 years, 43% of the interviewees are between 40–49 years, 9% of the interviewees are in the age range 50–59 and 14% of the interviewees were above 60 years of age. This indicates that the experience level was high and that the interviewees had various ranges of experience and knowledge. Their age also indicated intensive experience in the projects.

On the other hand, interviewees' nationalities were distributed to cover USA/Canada, Europe, Middle East and Far East with Asia. This presented the mixture of the interviewees' culture and social backgrounds, which emphasised on the project global reference and participation.



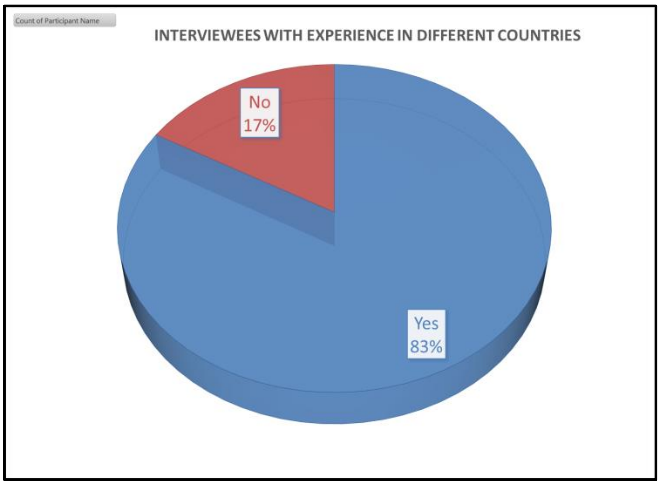


Figure (5.49) Interviewees experience in different countries and industries other than Oil & Gas

As shown in Figure (7.46) above, all interviewees have experience in more than one country and continent. This ascertains that the factors identified are globally applicable. Also it can be observed that all the interviewees have experience in industries other than Oil & Gas, such as infrastructure and power projects.

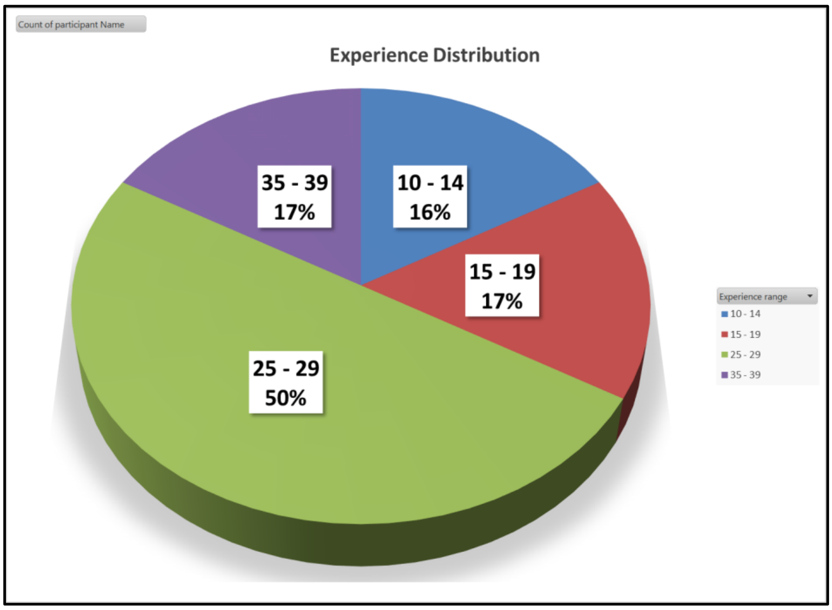


Figure (5.50) Experience Distribution of Interviewees

The experience of interviewees ranges from 10 years to 45 years, which represents the wide range of profiles of interviewees who have participated in the case study.

The fact that the interviewees have a wide range of experience in different countries/continents and have also worked in different countries and have a wide range of experience affirms that the experience applied in answering the case study questions is widely distributed. The diversified portfolio of the interviewees has allowed the input data for further investigation to be normalised.

5.5.7 Interviewee Feedback and Analysis

The case study again was put together in a similar way that the questions are maintained unbiased and encourages the interviewees gets into the subject in a progressive manner. The request for participation was also made to all interviewees through phone and subsequently emails were sent out with preliminary information on the nature of case study and the case study information Q&As.

During the interviews, several interviewees showed interest in understanding the purpose of this case study and the same was explained to all of the interviewees.

Also, some interviewees enquired about the level of confidentiality that would be maintained and the same was assured by the researcher.

The initial questions in Section A were designed to get interviewee feedback on the secondary factors collected and grouped from the literature. The interviewees took some time to respond and get adjusted to the nature of questions initially but later once they got in half way through the responses were quicker. In general, it was observed that the interviewees were interested in adding their perception against each of the factor presented to them and it was observed that many of the factors were related to each other. There were common observations that a proper communication and timely collection and proper recording and distribution of design information would be one of the major factors for a successful design phase in EPC projects. Most of the participants were of the view that all the factors agreed by them were encountered by them at some point of time during different phases of project executed by them.

There was a wide range of responses on the phase of occurrence of the impact of these factors depending on whether the interviewee was representing the client, contractor, sub-contractor or vendor. In general, it was a general perspective of the group that early information sharing and good communication throughout the project can prevent future changes and resulting impact on schedule and cost. The questions were drafted in such a manner to avoid repetitive questions.

It was noted during the interview that interviewees representing different stakeholders agreed on the factors but differed on their response to responsible stakeholders. For instance, a vendor is fed data in the form of design documents and in return has a level of influence restricted somewhat up to the EPC contractor. Similarly, the contractor acts as an intermediate link between the client and vendor or client and sub-contractor. Hence the communication between these elements is highly dependent on the interfacing capabilities of the contractor. Even though the direct question was avoided in this subject to keep an unbiased tone of the interview, most of the responses from the interviewees except those representing the EPC contractor was pointing towards insufficient information or delays from the EPC contractor. Some of the interviewees also insisted that an open communication channel between all the parties involved in the project from the early phase of the project can reduce the inefficiencies in the project activities.

In the second section, the interviewees were asked to share some background information regarding their experience in different countries and industries. At this stage, the interviewees were questioned about the delivery methods that they are familiar with and their view of IPD. Almost all the interviewees were well versed about several of the project contracting types and have worked personally for several such projects. It was observed that across the age group all the interviewees were open to adapt to IPD at a technical level, though they were uncertain on the contractual, commercial or legal implications of IPD as against the traditional project deliveries.

In the third section, when asked about the factors not identified in this question sheets, the interviewees' responses indicated improper communication between various stakeholders from early stages of projects, improper planning, non-performance of vendors and delays in government permits as few prominent factors.

The interviewees were asked about the ID and the framework; the majority had no have experience with the IPD approach and tried again to link it to another execution strategy, similar to partnering and alliancing. Also the interviewees were confused how to apply the IPD and how it was possible to bring the contractor into the design early before the award had started. The other understanding and questions were that if the contractor will influence his ideas and selection strategy.

The researcher has collected all the comments and started answering one by one, such as the contractor participation is to review the design documents and to ensure no vagueness in these deliverables. Participation by one contractor members or by several should have the same objective by improving the design quality and making the scope much clear for bidding purposes.

The formwork was also explained to all interviewees and they have acknowledged that the identified factors can be resolved if the stakeholders are involved together. The design factor along with poor schedule understanding will be resolved if vendors and subcontractors are participating during the design. Also other cost estimate will be improved by more participants from the manufacturers' side early involvements. Also interviewees have requested if possible the framework is improved to cover other factors not mentioned in the list since participant might come with new problems and lessons. All interviewees were finding it difficult to bring the contractor as early as in the design and it will be difficult to draw their attention that early, however some of the participants also mentioned having one representative from each contractor and other stakeholder could be enough to carry and cascade majority of the poor performance factors. The emphasis was that if the contractor reviews the design document, he will easily discover the shortfalls and gaps, which will allow the designer to correct and improve. Also one of the interviewees requested to change the stakeholder from the EPC contractor to EPC bidders, where more than one contractor is participating at the bidding, then the framework can add one more stakeholder as the awarded contractor. The duration was also debatable by the interviewees, since it varies between each project and was proposed to be more flexible and longer to cover different times, i.e. it was proposed to avoid having the number of months and enough to mention the phase, such as FEED, design, procure and construct.

5.5.8 Third Case Study Results

The third case study was conducted with the inputs from the key role stakeholders representing Client, Project Management Consultant (PMC), Designing consultant (FEED), Major Equipment (ICS) Vendor & Construction Contractor (EPC) and subcontractor of Oil production facility upgrade project. "Oil Production facility upgrade Project" was executed with an objective to supplement 40,000 barrels of oil per day (BOPD) sustainable production at degassing facilities and supply required water injection rates to support production. The modification works included adding new oil producer wells & water injection wells, upgrades to existing oil gathering facilities.

The results are plotted in various graphs in order to validate the factors (secondary) and their collected impact. Based on the inputs from interviewees, the results were carefully analysed to assess their existence, frequency of occurrence and phases of occurrence, in addition to the similarities and to find out the consistency from the stakeholders' perspective.

The results were analysed taking into consideration the following factors:

1. The stakeholders who have participated in the interview look at the project and analyse the delays from their perspective. For example, a vendor who has got delayed approvals on his engineering documents will assume that the delay is because of delayed client approvals, whereas the actual reason may be improper design in the first place.
2. The above presented stakeholders were involved in different phases of the project and in some of the cases not in all phases of the project due to the Design – Bid – Build strategy followed in the project. However, only the client and PMC have the complete project experience cycle through all the phases, therefore the feedback will be based on the participated phase for each interviewee.
3. The natural human instincts to protect one's own interest and organisational interest can influence the responses of the interviewees; however, the researcher tried to share the factors in a project prospective and this condition could impact the responsible stakeholders on the delay, where consistency will be seen in other questions.
4. The interview being repetitive in the nature of questions, with so many inputs could have possibility of human error while assessing and replying to the questions; however, the researcher tried to ensure that the interviewees are focused and their answers are relevant by opening the discussion and by providing some clarification and suggestions with real projects' examples to ease the answers. With the initial data

filtering/cleaning, it can be assumed that the margin of error will be minimal.

5. The interviewee's global experiences and their execution to various projects in various countries have provided a global feedback and no major specific regional responses were influencing the feedback.
6. The following graphs were plotted for the first case study based on the interviews' results.

- Factor (Secondary Data) Validation by Individual Interviewee
- Factor (Secondary Data) Validation by Individual Factor
- Design Phase Factors (occurrence & resolvable) by individual Interviewees
- Design Phase Factors (occurrence & Resolvable) by Individual factor
- Tendering Phase Factors (occurrence & resolvable) by individual Interviewees
- Tendering Phase Factors (occurrence & Resolvable) by Individual factor
- EPC Phase Factors (occurrence & resolvable) by individual Interviewees
- EPC Phase Factors (occurrence & Resolvable Early) by Individual factor
- Factors resolvable by Early Stakeholder Engagement (by individual Interviewees)
- Factors resolvable by Early Stakeholder Engagement (by Individual factor)
- Factors phase of Occurrence (by individual Interviewees)
- Factors phase of Occurrence (by Individual factor)

5.5.8.1 Factor (Secondary Data) Validation by Individual Interviewee.

The bar chart below shows the factors (secondary data), where interviewees have agreed/confirmed that they are a reason for in project and also agreed that the factors whether can be resolved during early design phase. The following observations can be made from the results:

1. On average it can be read that Client & PMC interviewees have an agreement in a large number, i.e. an average of, 97% of the key factors identified from literatures have agreed into (secondary Data) (average of 37 out of 38 factors).
2. The client and PMC have also agreed that the majority of these factors are resolvable during early design phase of the project. Some 36 of 38 factors have been voted resolvable by Client & PMC representatives. This again provides solid and genuine feedback from a stakeholder who has participated in the entire project cycle (phases).

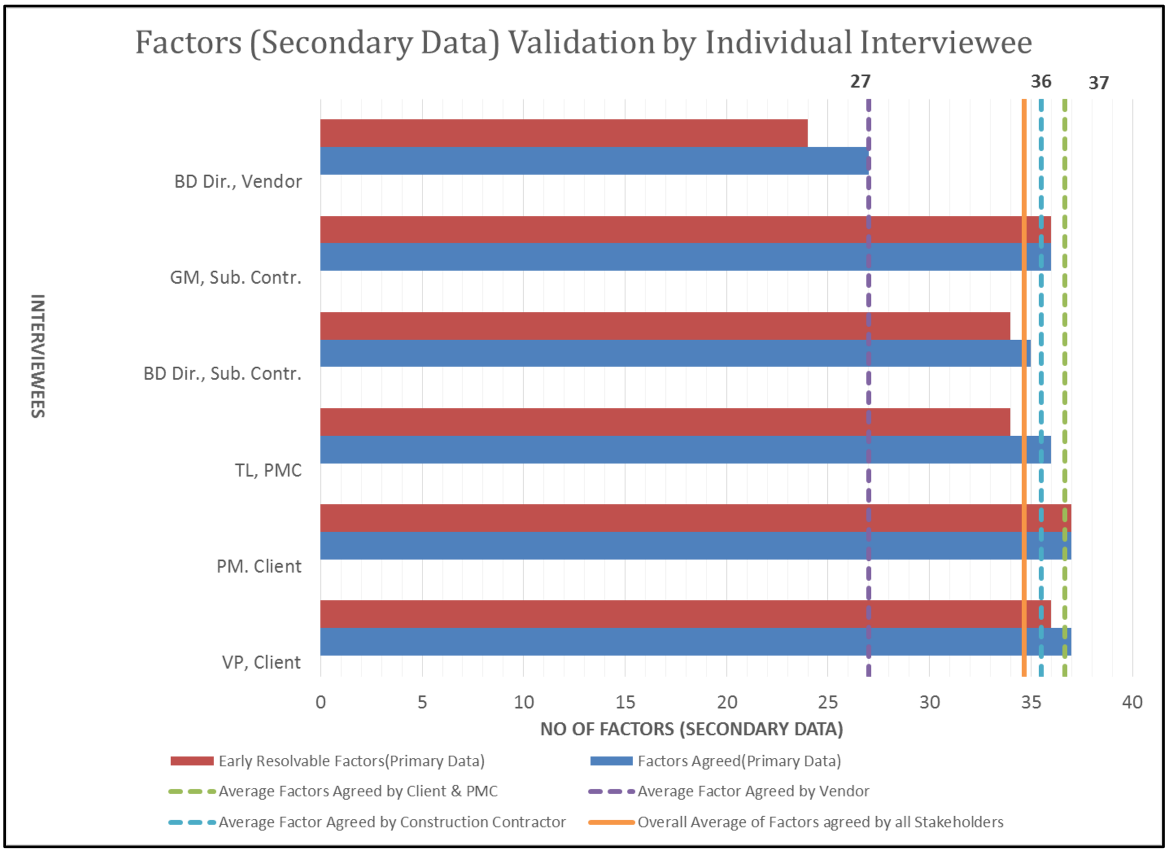


Figure (5.51) Factor (Secondary Data) Validation by Individual Interviewee

3. The construction contractor has agreed to 92% of the factors from the literature (Secondary data) (average 35 out of 38 factors).
4. The Vendor has agreed to an average of 71% of the factors from the literature. The following factors are considered as factors with no impact on project performance by the vendor:

2. Insufficient team building during design and EPC

5. Project manager does not have full authority

8. Excessive bureaucracy in owner's organisation

11. Lack of IT use in communication and information management

12. Lack of mechanism for recording, analysing, and transferring project lessons learned

15. Inadequate or improper planning from owner to deliver the project

16. Poor estimation of labour productivity by EPC

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

29. Delay in Tendering and award schedule

31. Delay in procurement by contractor

37. Delay in procurement by contractor

5.5.8.2 Factor (Secondary Data) Validation by Individual Factor

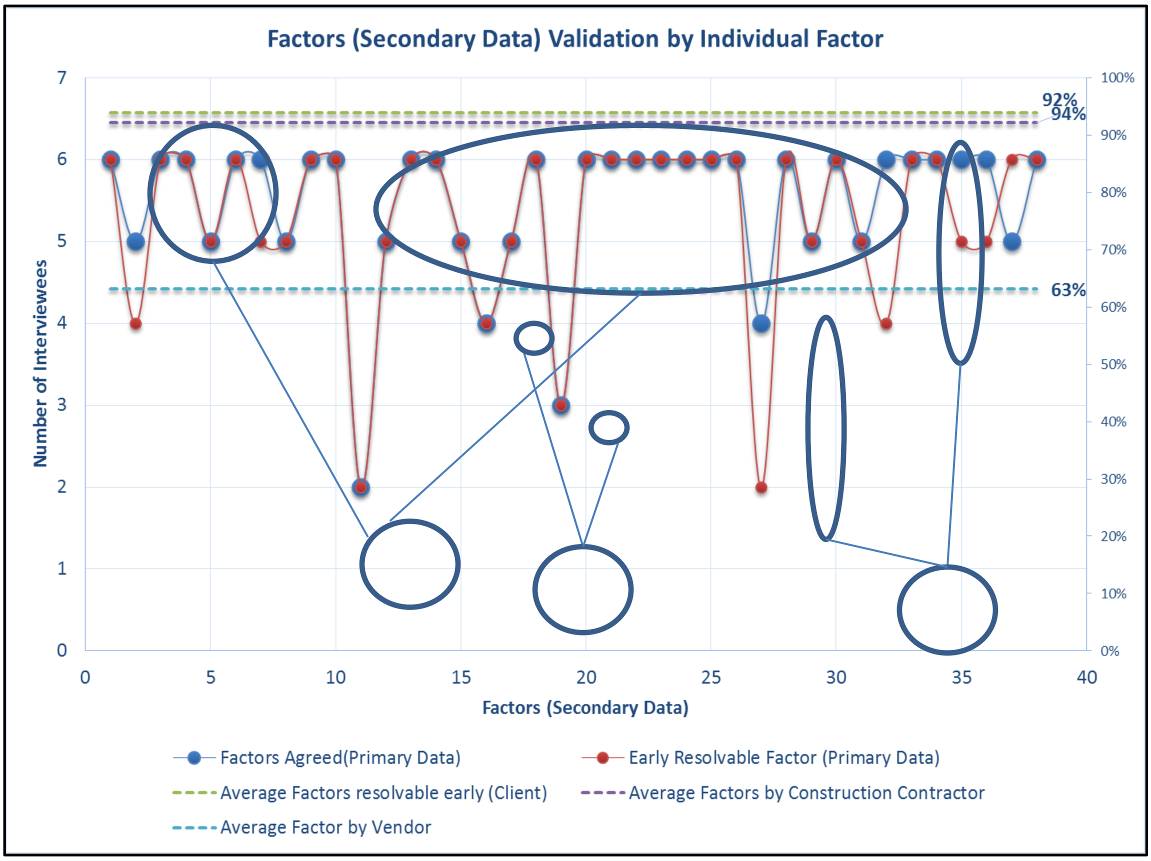


Figure (5.52) Factor (Secondary Data) Validation by Individual Factor

This graph above shows the consistency of responses by all stakeholders for the factors identified from the secondary data source. The following observations to be noted from the above:

1. In general, it can be observed from the above graph that where an interviewee has agreed to a factor which affects the project, the majority have also agreed that it is resolvable early during the project design phase, hence the red & blue lines are seen either overlapping or very close to each other, as highlighted by data point 1.
2. The highlighted data point 2 above show that less number of interviewees have agreed on the factors, but the point to be noted is that almost all who have agreed on the occurrence of the factor have agreed that it can be resolved during early design phase. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

   11. Lack of IT use in communication and information management
   16. Poor estimation of labour productivity by EPC
   19. Mega size, design complexity and complications

3. The highlighted data point 3 above shows the anomaly where in interviewees have encountered the factor in their past experience but only a few believe it is resolvable during early design. The factors are:

   27. Outdated design software.
   32. Financial issues of contractor during execution

5.5.8.3 Design Phase Factors (Occurrence & Resolvable) by Individual Interviewees

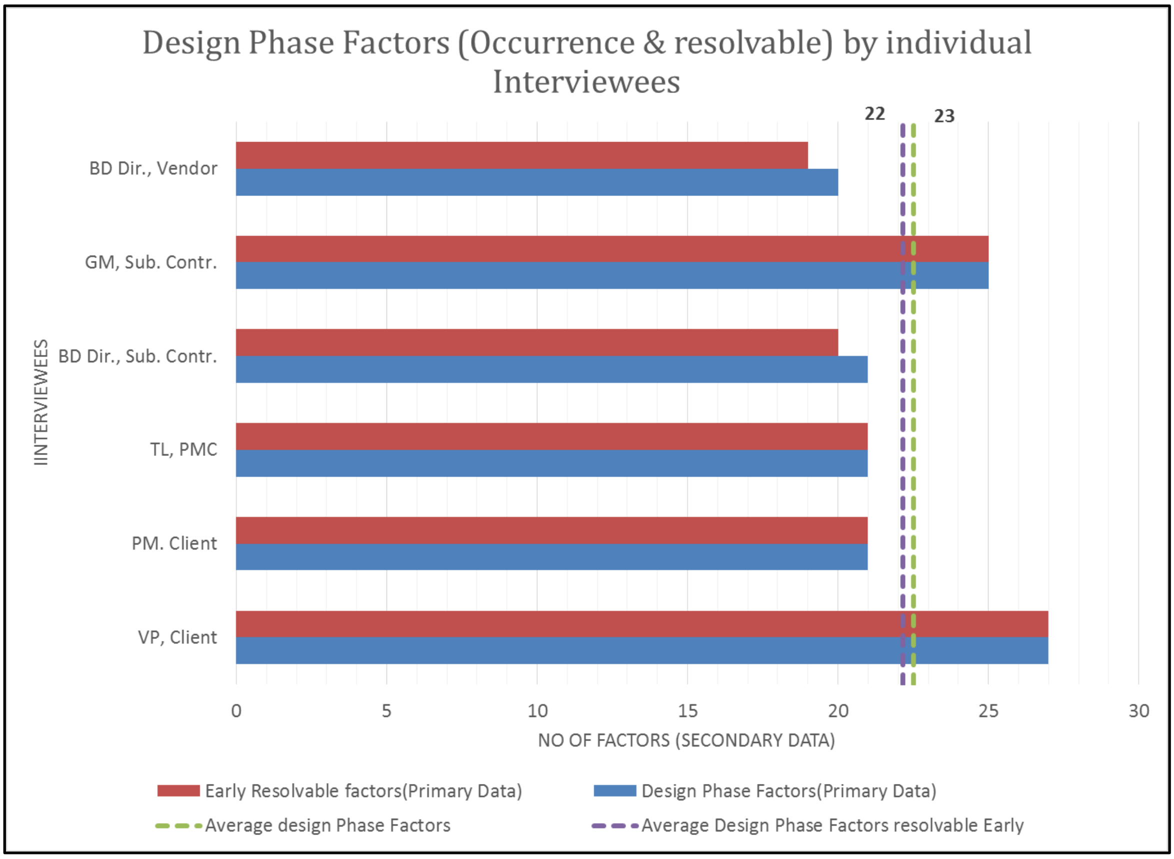


Figure (5.53) Design Phase Factors (occurrence & resolvable) by individual Interviewees

Graph plots interviewees' responses on the number of factors which occurs during the design phase of the project and the number of factors that are resolvable during early design phase involvement from the stakeholders. The graph also shows the average number of responses on the factors occurring during the design phase of the project as agreed by interviewees and the average number of factors resolvable during early design phase. The following observations can be made from the above;

1. Of the factors agreed to be occurring in the design phase by the interviewees, they also believe that most of these factors can be resolved during early design phase of the project.

2. On average 23 of the 38 factors (60%) are believed to occur in design phase by the interviewees of which majority have been agreed resolvable early by the interviewees.

5.5.8.4 Design Phase Delay Factors (Occurrence & Resolvable) by IndividualDelay factor

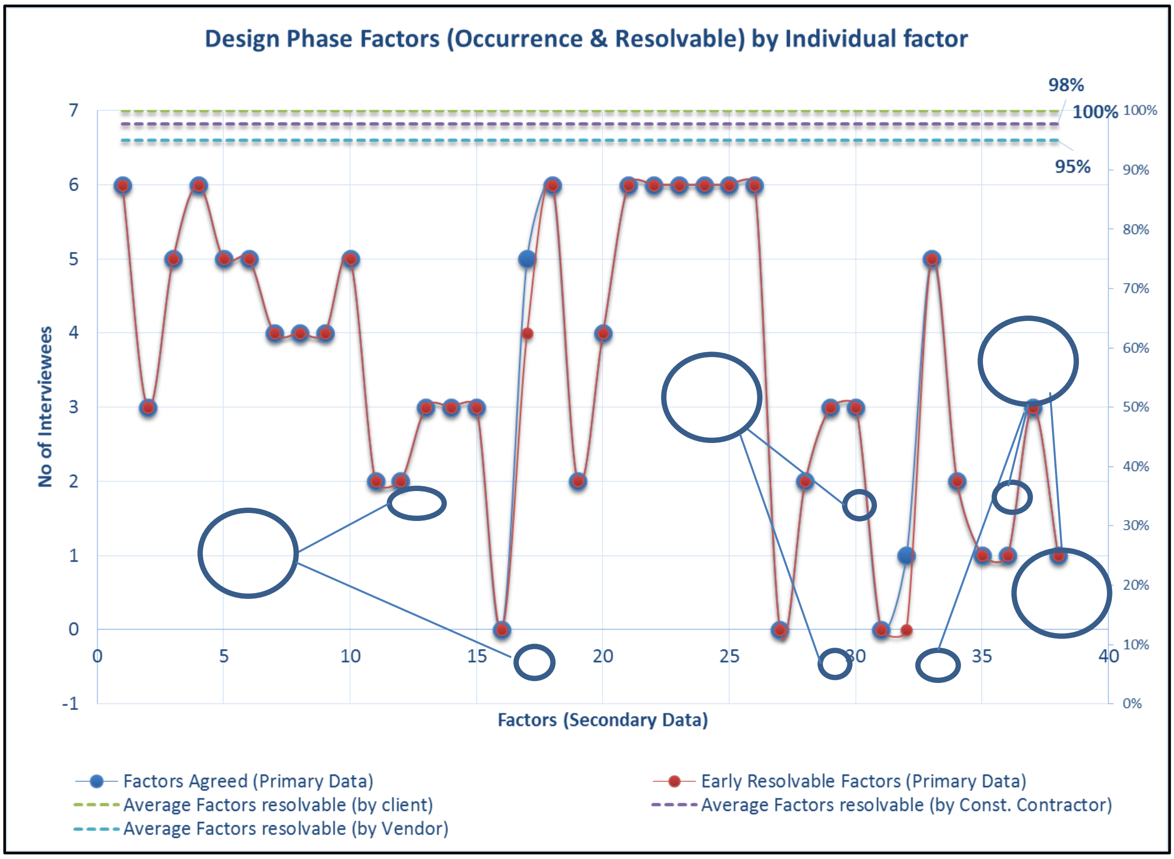


Figure (5.54) Design Phase Delay Factors (Occurrence & Resolvable) by Individual Delay Factor

Graph shows how many of the interviewees have agreed that each factor occurring in the design phase of a project is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewees' group (client/PMC, vendor & construction contractor) average on the number of factors resolvable during the early design phase from the ones agreed to be occurring in design phase of the project. The following can be inferred from the graph:

1. On average it can be observed that almost all of the interviewees have responded with confirmation that all the agreed factors occurring during design phase, almost all of them can be resolved during early design phase.
2. As highlighted in the data point 1, some of the factors have been considered to occur less frequently during the design phase by interviewees. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

11. Lack of IT use in communication and information management

12. Lack of mechanism for recording, analysing, and transferring project lessons learned

16. Poor estimation of labour productivity by EPC

27. Outdated design software

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

31. Delay in procurement by contractor

32. Financial issues of contractor during execution

34. Flexibility of client to adopt technical changes

35. Less time for EPC tendering and too many bidders

36. Limited capability of contractor

38. Poor technical decision during tendering by PMC

5.5.8.5 Tendering Phase Factors (Occurrence & Resolvable) by Individual Interviewees

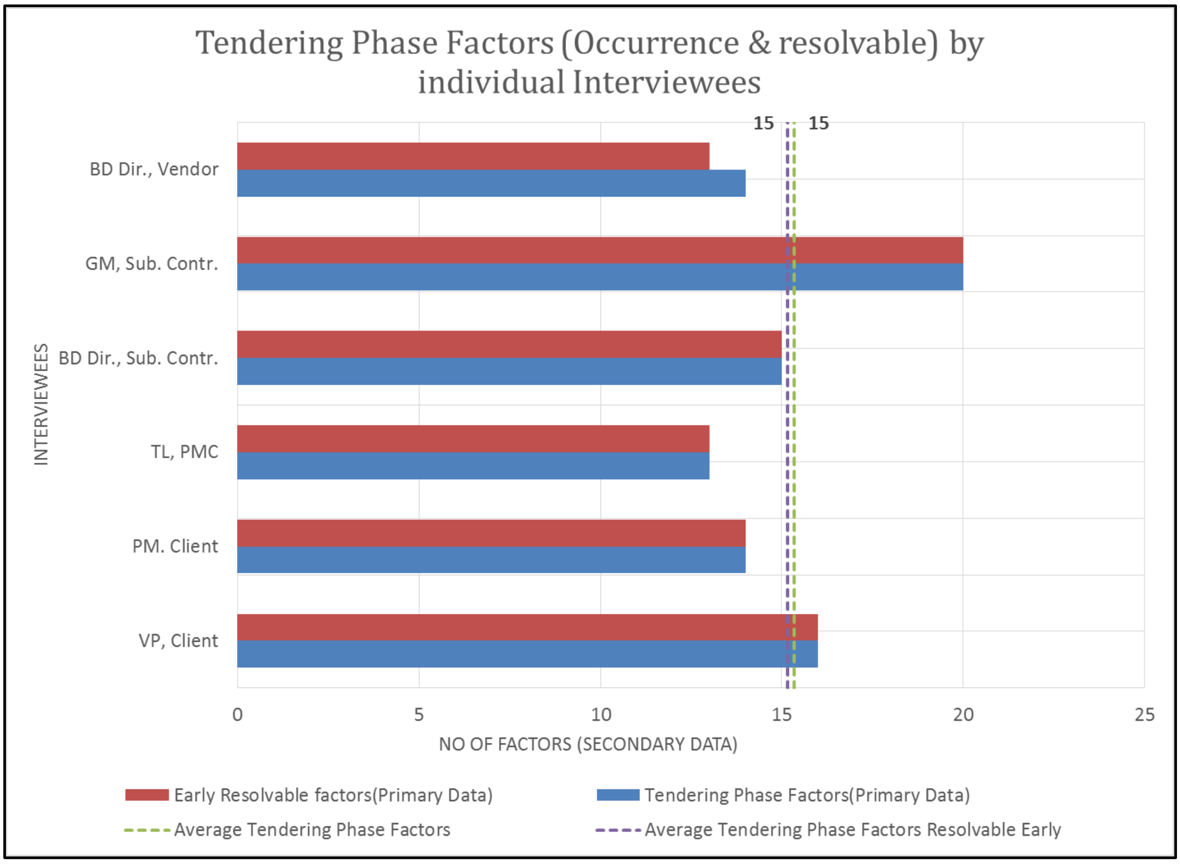


Figure (5.55) Tendering Phase Factors (Occurrence & Resolvable) by Individual Interviewees

The graph plots interviewees' responses on the number of factors which occur during the Tendering phase of the project and number of these factors that are resolvable during the early design phase. The graph also shows the average number of responses on the factors occurring during the tendering phase as agreed by interviewees and the average number of factors resolvable during early design phase.

1. Of the factors agreed to be occurring in the Tendering phase by the interviewees, the interviewees believe that most can be resolved during the early design phase of the project.
2. On average, 15 of the 38 factors (40%) are believed to occur in the Tendering phase by the interviewees, of which the majority are believed to be resolvable early on by the interviewees.

3. It was noticed that interviewees believe that although Tendering has an impact on project delays due to short tendering duration and time limitations, interviewees believe that the Tendering phase has less of an impact compared to the Design and Construction phases.

5.5.8.6 Tendering Phase Delay Factors (Occurrence & Resolvable) by Individual Delay Factor

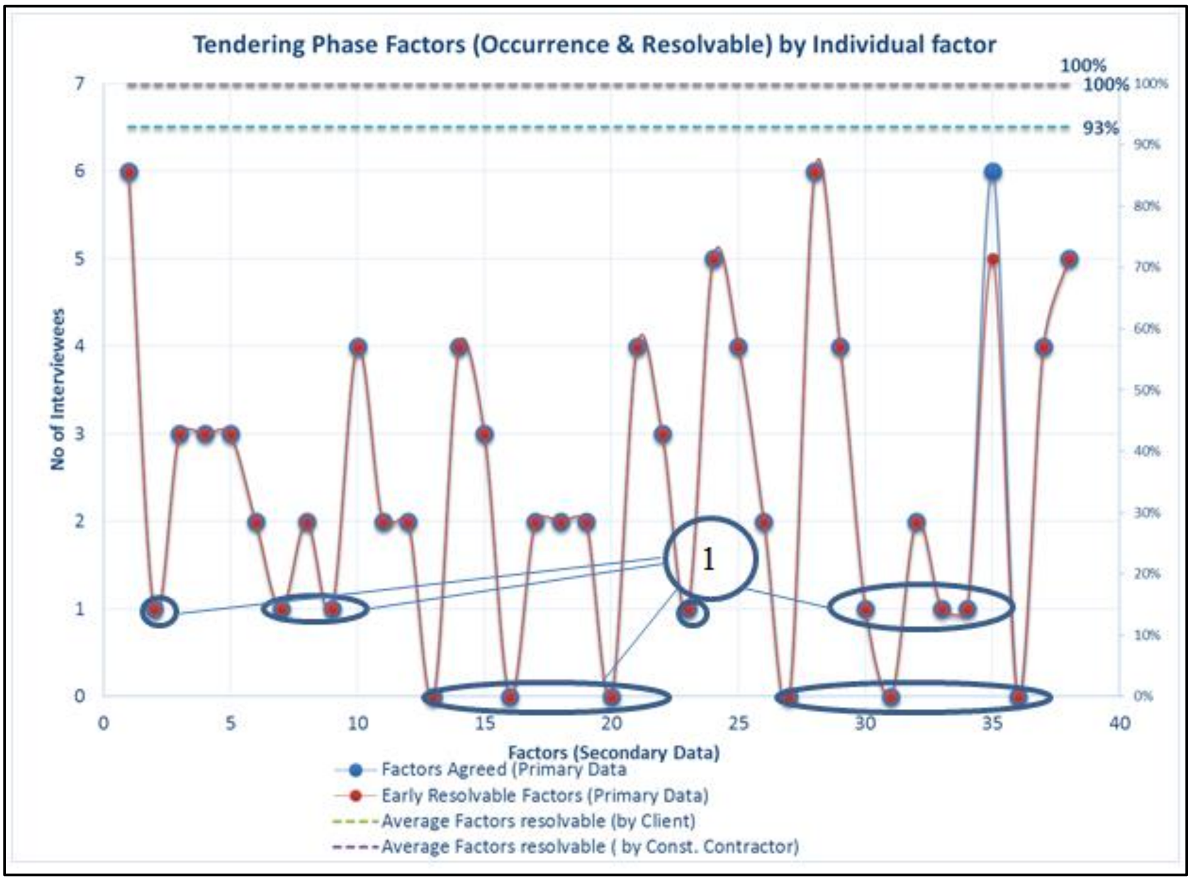


Figure (5.56) Tendering Phase Delay Factors (Occurrence & Resolvable) by Individual Delay Factor

This graph shows how many of the interviewees have agreed that each factor occurring in the Tendering phase of a project is a reason for project delay, and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewee group (client/PMC, vendor & construction contractor) average on the number of factors resolvable during the early design phase from the ones agreed to be occurring in the Tendering phase of the project.

1. On average, it can be observed that almost all of the interviewees have responded that of the agreed factors occurring during the Tendering phase, almost all of them can be resolved during the early design phase.
2. The majority of the interviewees consider these factors, as highlighted in data point-1 above, as not occurring in the Tendering Phase. Below are the factors which fall under this category (point numbers represent the survey questions numbering):

2. Insufficient team building during design and EPC

7. Frequent owner interference

9. Issues regarding permissions/ approvals from other stakeholders

13. Inadequate control procedures from owner side to monitor the progress and delay

16. Poor estimation of labour productivity by EPC

20. Design variations or changes in client requirement

23. Poor quality of deliverables by FEED Designer

27. Outdated design software

30. Inadequate contractor experience - all phases, unfamiliar with regulations, policies & local law changes or issues and lack of knowledge in social & cultural factors

31. Delay in procurement by contractor

33. Delay in mobilization during Design & EPC

34. Flexibility of client to adopt technical changes

36. Limited capability of contractor

5.5.8.7 EPC Phase Factors (Occurrence & Resolvable) by Individual Interviewees

This graph plots interviewees' responses on the number of factors which occur during the Construction (EPC) phase of the project and number of factors that are resolvable during the early design phase if they are addressed properly. The graph also shows the average number of responses on the factors occurring during the EPC phase as agreed by interviewees and the average number of factors resolvable during the early design phase.

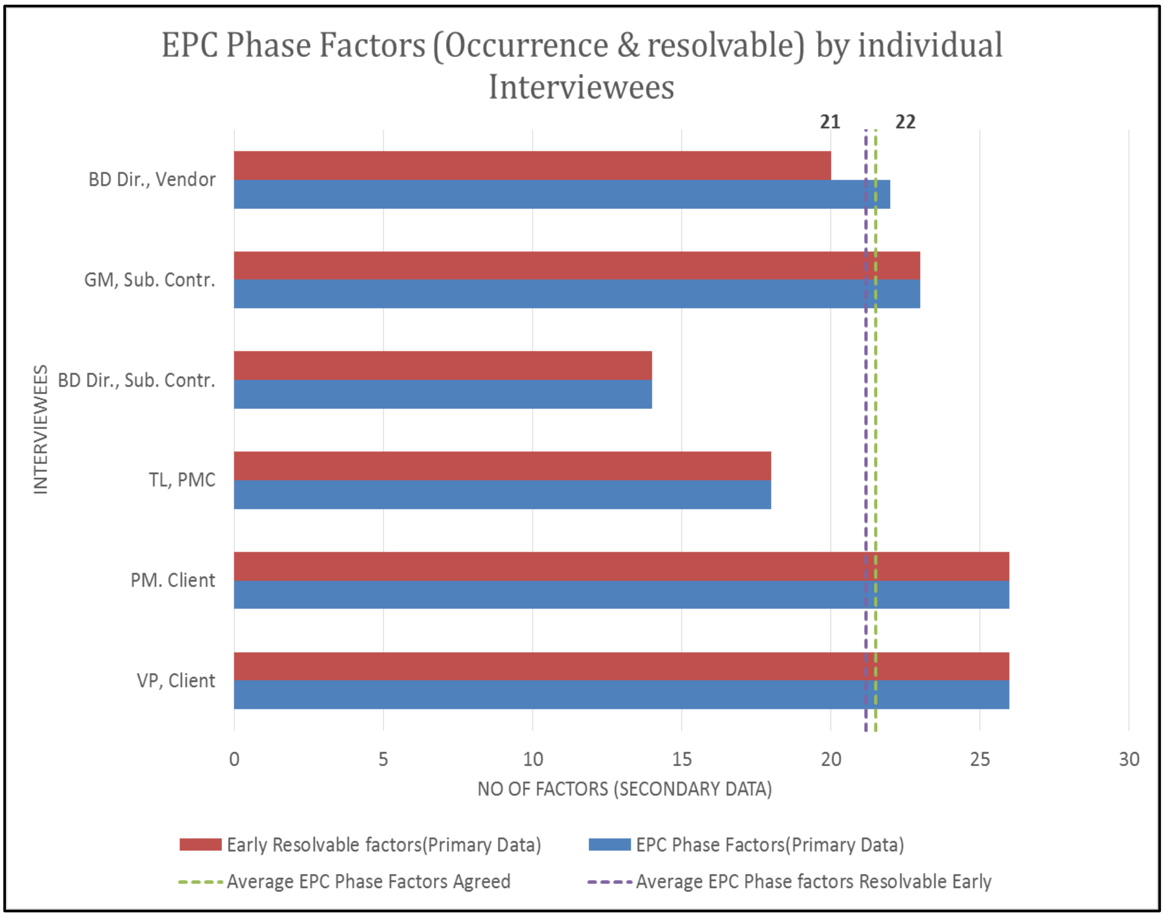


Figure (5.57) EPC Phase Factors (Occurrence & Resolvable) by Individual Interviewees

The following observations were made from the graph above:

1. Of the factors agreed to be occurring in the EPC phase, almost all of the stakeholders believe that most of the factors can be resolved during the early design phase of the project.

2. On an average 22 of the 38 factors (58%) are believed to occur in the EPC phase by the interviewees of which majority has been agreed resolvable early by the interviewees.

5.5.8.8 EPC Phase Delay Factors (occurrence & Resolvable Early) by Individual Delay factor:

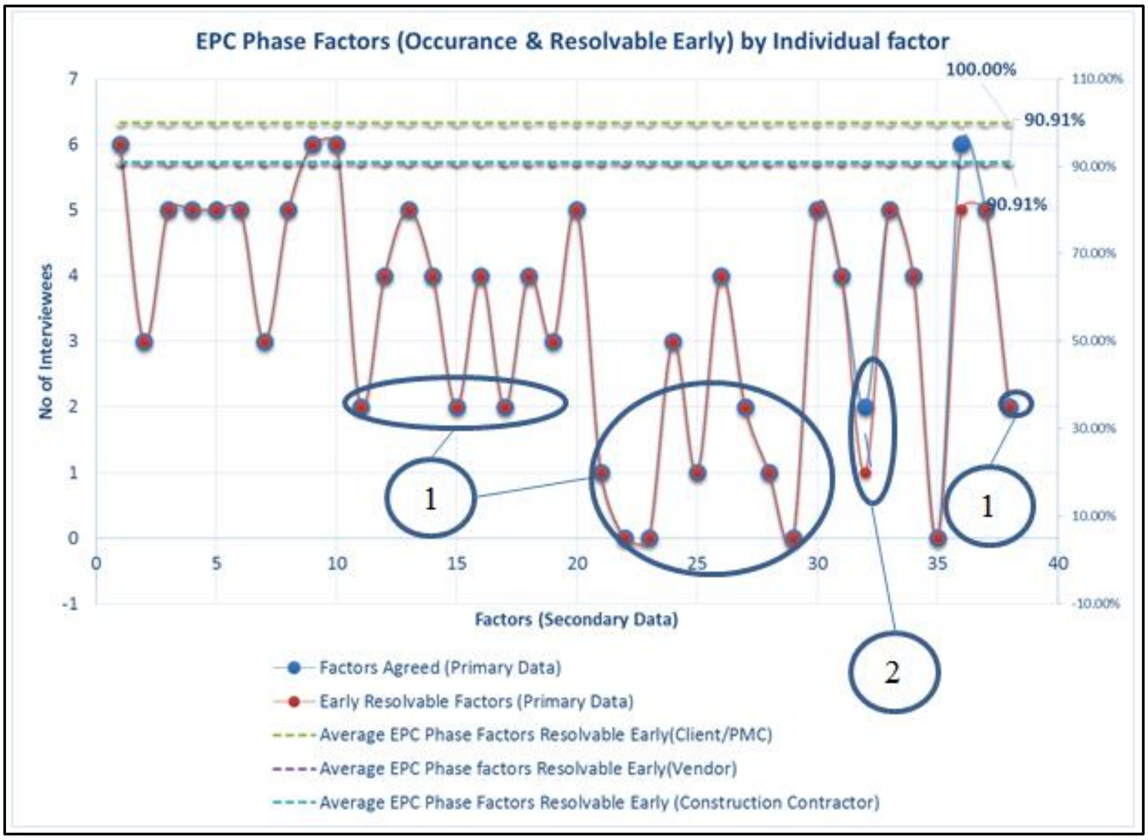


Figure (5.58) EPC Phase Delay Factors (Occurrence & Resolvable Early) by Individual Delay Factor

This graph shows how many of the interviewees have agreed that each factor occurring in the EPC phase of a project is a reason for project delay and how many of the interviewees have agreed that each of these factors can be resolved during the early design phase of the project. The graph also plots the interviewee group (client/PMC, vendor & construction contractor) average on the number of factors resolvable during the early design phase from the ones agreed to be occurring in the EPC phase of the project. The observations from the above graph are as follows:

1. In general, it can be noticed that out of the agreed number of factors by the stakeholder groups, an average of 98% factors are considered as resolvable early on by construction contractors, 96% of factors are considered resolvable early on by the client and 90% of factors resolvable early on by the vendor. The maximum anomaly can be found in the case of the vendor where factors are considered as not being resolvable early.
2. As highlighted in data point 1 above, the majority of the interviewees have considered these factors to occur during the EPC phase by a lower number of interviewees. Below are the factors which fall under this category, (point numbers represent the survey questions numbering):

11. Lack of IT use in communication and information management

15. Inadequate or improper planning from owner to deliver the project

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

21. Inadequate project objective and scope definition by owner and FEED designer

22. Lack of engineering clear roles/goals

23. Poor quality of deliverables by FEED designer

25. Lack of Communication between FEED engineers and other stakeholders (operation & maintenance)

27. Outdated design software

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in Tendering and award schedule

32. Financial issues of contractor during execution

35. Less time for EPC tendering & too many bidders

38. Poor technical decision during tendering by PMC

3. Data point 2 highlights the factor which is believed to occur during the EPC by many interviewees, even though comparatively fewer interviewees

have agreed that it is resolvable during the early design phase of the project. The factor highlighted is:

32. Financial issues of contractor during execution

5.5.8.9 Factors Resolvable by Early Stakeholder Engagement (by Individual Interviewees)

This graph plots the individual interviewee response on the number of factors from the secondary data which occur during the project, number of factors resolvable during early design phase, and the number of factors which require early engagement of stakeholders for resolving the factors, who generally get involved in the later stages of project viz. construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors.

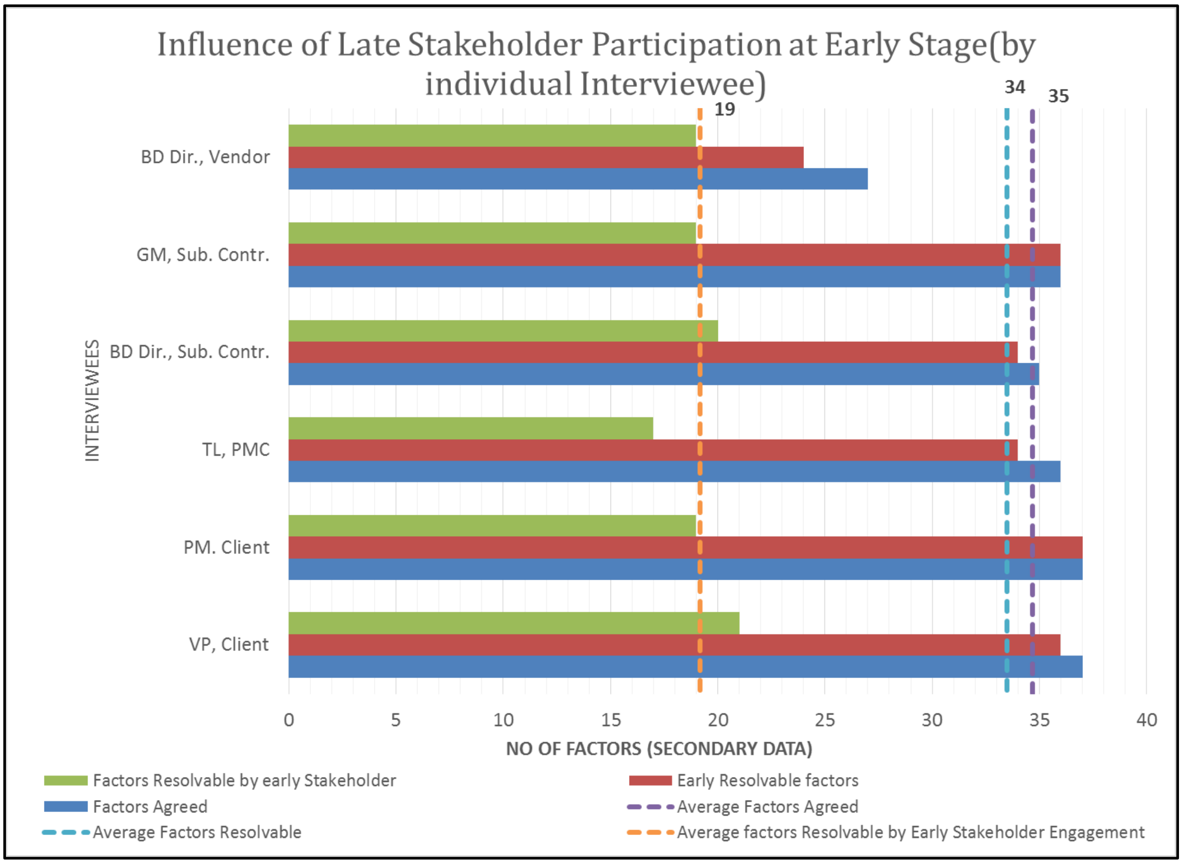


Figure (5.59) Factors Resolvable by Early Stakeholder Engagement (by Individual Interviewees)

The following observations can be made from the above graph:

1. About an average of 50% of the factors agreed by interviewees can be resolved by early engagement of late stakeholders during early design phase. These stakeholders are generally identified and involved usually at later stages of the project viz. construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors.
2. About 38% of the factors can be resolved during the early design phase without any early engagement of construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors.
3. An overall average of 88% of the factors selected from secondary data can be resolved during early design phase.

5.5.8.10 Factors Resolvable by Early Stakeholder Engagement (by Individual Delay Factor):

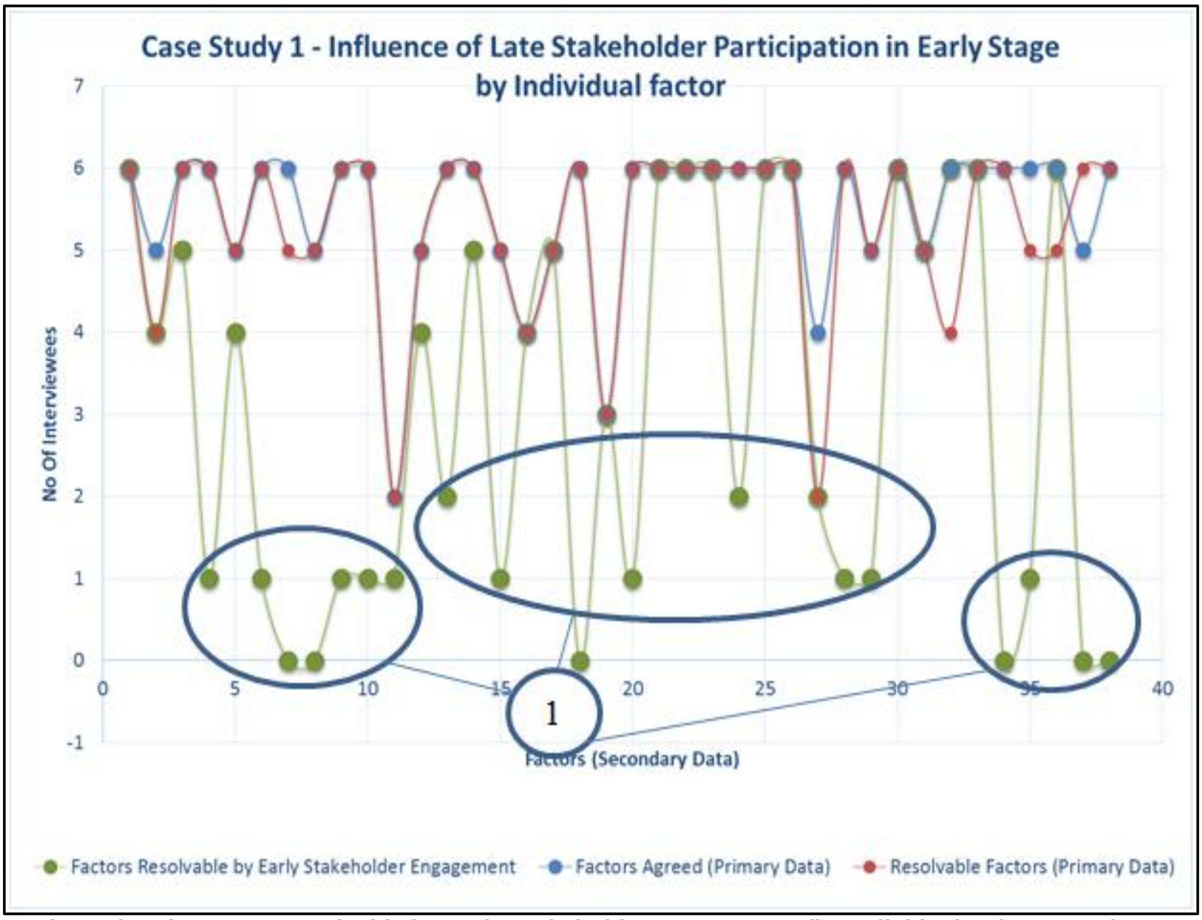


Figure (5.60) Factors Resolvable by Early Stakeholder Engagement (by Individual Delay Factor)

This graph shows how many of the interviewees have agreed that each factor occurring in the Construction (EPC) phase of a project is a reason for project delay, how many of the Interviewees have agreed that each of these factors can be resolved during the early design phase of the project, and how many interviewees have agreed that each of the factors require early engagement of stakeholders for resolving the factors, who generally get involved in the later stages of project viz. construction contractor, major & minor equipment manufacturers and specialist consultant/sub-contractors.

1. From the data points 1 selected above, it can be seen that a number of factors (approximately 38%) can be resolved without early engagement of construction contractor, major and minor equipment manufacturers and specialist consultant/sub-contractors, even though early engagement of these stakeholders can improve the quality and schedule. The following are the factors which fall under this category, (point numbers represent the survey questions numbering):

   4. Conflicts/disputes between owner stakeholders (project team and operations)

   6. Insufficient & inexperienced management personnel from owner

   7. Frequent owner interference

   8. Excessive bureaucracy in owner's organisation

   9. Issues regarding permissions/approvals from other stakeholders

   10. Slow decision-making and lack of staff involvement from owner side

   11. Lack of IT use in communication and information management

   13. Inadequate control procedures from owner side to monitor the progress and delay

   15. Inadequate or improper planning from owner to deliver the project

   18. Lack of client participation in major milestones during design

   20. Design variations or changes in client requirement

   24. Delayed or insufficient design information from owner

   28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

   29. Delay in Tendering and award schedule

34. Flexibility of client to adopt technical changes
35. Less time for EPC tendering & too many bidders
37. Limited authority of PMC consultant
38. Poor Technical decision during tendering by PMC

5.5.8.11 Factors phase of Occurrence (by individual Interviewees):

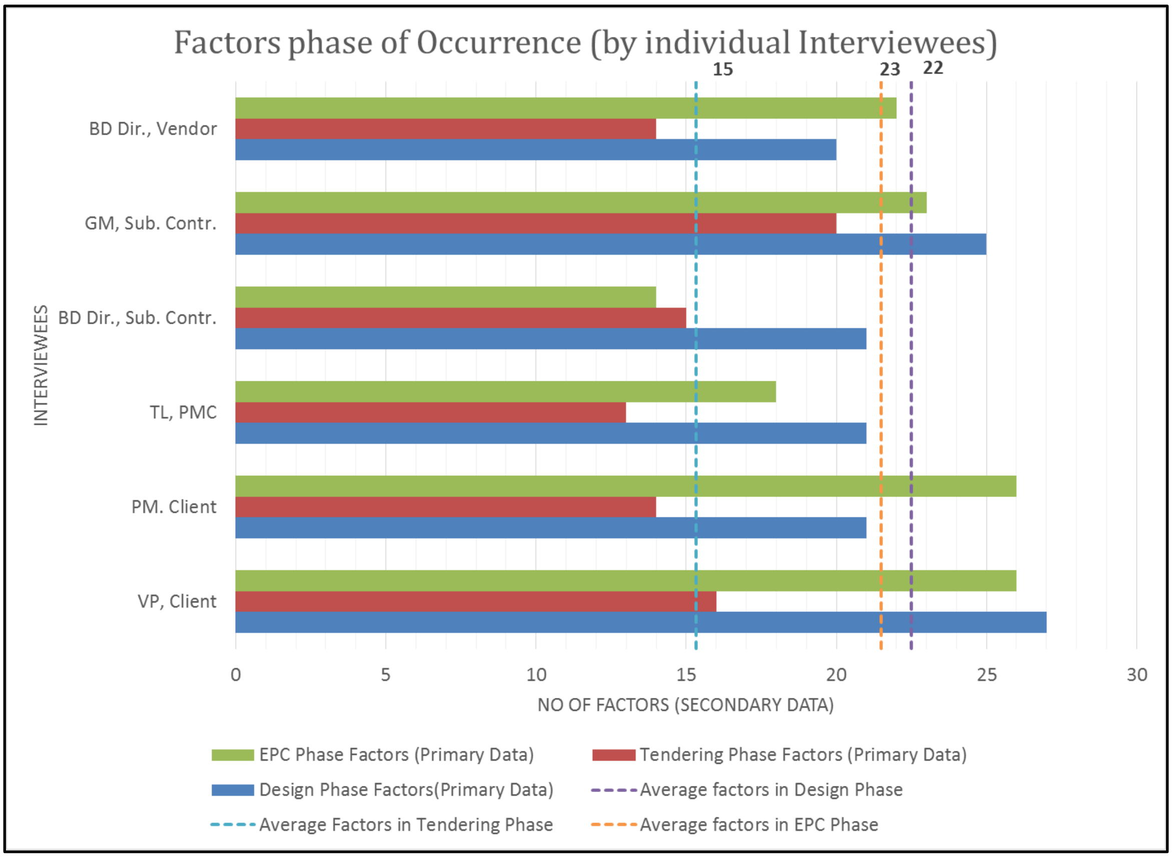
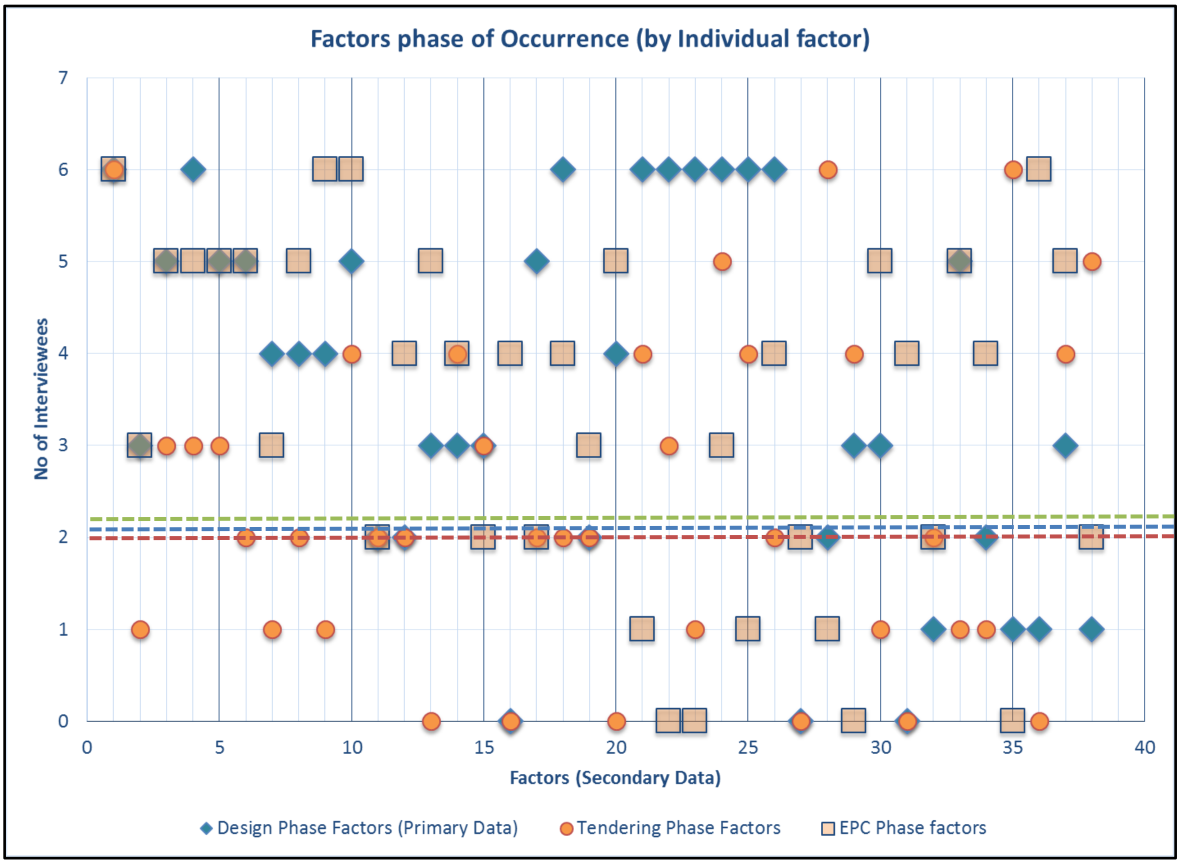


Figure (5.61) Factors Phase of Occurrence (by Individual Interviewees)

This graph shows individual interviewees' feedback regarding how many factors occur in each phase of the project.

1. Based on the interviewee feedback, about 60% of the delays occur during the design phase of the project, 39% occur during Tendering and 58% occur during the EPC phase.
2. All groups of interviewees (client/PMC, vendor and construction contractor) have agreed on an average the highest number of factors (selected from secondary data) occur during Design followed by EPC and least number of factors occur during tendering.

5.5.8.12 Factors Phase of Occurrence (by Individual Delay Factor):



EPC Threshold   Tendering Threshold   Design Threshold

Figure (5.62) Factors Phase of Occurrence (by Individual Delay Factor)

This graph shows by individual factor how many interviewees have voted that a factor can occur in each of the phases of the project. viz., design, tendering and EPC

1. From the graph above it can be observed that very few interviewees have voted for some of the factors which occur in the phases covered by the highlighted region in the graph above. The researcher, after referring to each mentioned factor, realised that interviewees' answers are relevant and these factors irrelevant to the phase of the project. Some of the examples for factors not expected to occur under each of the phases are listed below:

2. Factors not expected to occur during Design, (point numbers represent the survey questions numbering):

11. Lack of IT use in communication and information management
12. Lack of mechanism for recording, analysing, and transferring project lessons learned
16. Poor estimation of labour productivity by EPC
19. Mega size, design complexity and complications
27. Mega size, design complexity and complications
28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding
32. Financial issues of contractor during execution
34. Flexibility of client to adopt technical changes
35. Less time for EPC tendering and too many bidders
36. Limited capability of contractor
38. Poor technical decision during tendering by PMC

3. Factors not expected to occur during Tendering, (point numbers represent the survey questions numbering):

2. Insufficient team building during design and EPC.
6. Insufficient & inexperienced management personnel from owner
7. Frequent owner interference
8. Excessive bureaucracy in owner's organisation
9. Issues regarding permissions/ approvals from other stakeholders
11. Lack of IT use in communication and information management
12. Lack of mechanism for recording, analysing, and transferring project lessons learned
13. Inadequate control procedures from owner side to monitor the progress and delay
16. Poor estimation of labour productivity by EPC
17. Delay in preparation and approval of documents by owner and FEED consultant/contractor
18. Lack of client participation in major milestones during design
19. Mega size, design complexity and complications
20. Design variations or changes in client requirement

23. Poor quality of deliverables by FEED designer

26. Lack of Communication between FEED engineers and other stakeholders (operation & maintenance)

27. Outdated design software

30. Inadequate contractor experience - all phases, unfamiliar with regulations, policies and local law changes or issues and lack of knowledge in social and cultural factors

31. Delay in procurement by contractor

32. Financial issues of contractor during execution

33. Delay in mobilization during design & EPC

34. Flexibility of client to adopt technical changes

36. Limited capability of contractor

4. Factors not expected to occur during EPC, (point numbers represent the survey questions numbering):

11. Lack of IT use in communication and information management

15. Inadequate or improper planning from owner to deliver the project

17. Delay in preparation and approval of documents by owner and FEED consultant/contractor

21. Inadequate project objective and scope definition by owner and FEED designer

22. Lack of engineering clear roles/goals

23. Poor quality of deliverables by FEED Designer

25. Lack of communication between FEED engineers and other stakeholders (operation & maintenance)

27. Outdated design software

28. Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding

29. Delay in Tendering and award schedule

32. Financial issues of contractor during execution

35. Less time for EPC tendering and too many bidders

38. Poor Technical decision during tendering by PMC

5.7 Case Studies Discussions and Feedback

All the case studies had various feedback and observations. Upon the interviews completed, the research has gathered the shared concerns and suggestions between all the interviewees. It was observed there was an agreement among majority of the interviewees in several findings; such as; Oil and gas projects are similar to general construction in terms of the execution and poor performance, however more complexity in terms of design and procurements. Most of the interviewees have worked in both sectors; Oil & Gas and general construction sector and they have commented that there is a similarity in the factors in both sectors.

Oil & Gas sector does not vary from region to region, interviewees those who have worked in different regions and continents, have expressed their common issues and problems and they confirmed that factors are occur with the same project types in different location, however environments, government concerns and resources are varying between locations. In terms of project management, planning, design and communication are the major group of poor performance and factors are repeated.

There was consensus between the interviewees that the presented factors represent the major factors behind poor performance, but each interviewee emphasized on specific encountered factor and group. The common group was the poor design, which usually led to other factors and problems. The role of the project management team toward the design was very crucial from the interviewee's point of view. The common findings were that design and poor management always linked together and they represent the key factor behind the performance and they are repeated in every project.

It was observed that the interviewees were interested in adding their perceptions against each of the factor presented and it was observed that many of the factors were related to each other. There were common observations that a proper communication along with timely collection and proper recording and distribution of design information would be one of the major factors for a successful design phase in EPC projects. Most of the interviewees were of the view that all the factors agreed by them were encountered by them at some point of time during different phases of project executed by them.

There was a wide range of responses on the phase of occurrence of the impact of these factors depending on whether the interviewee was representing the client, contractor, sub-contractor or vendor. In general, it was a general perspective of the group that early information sharing and good communication throughout the project can prevent future changes and resulting impact on schedule and cost. It was noted also during the interviews that interviewees representing different stakeholders agreed on the factors but differed on their response to responsible stakeholders. For instance, a vendor is fed data in the form of design documents and in return has a level of influence restricted somewhat up to the EPC contractor. Similarly, the contractor acts as an intermediate link between the client and vendor or client and sub-contractor, hence the communication between these elements are highly dependent on the interfacing capabilities of the contractor. Even though the direct questions were avoided in this subject to keep an unbiased tone of the interviews, most of the responses from the interviewees except those representing the EPC contractor were pointing towards insufficient information or delays from the EPC contractor. Some of the interviewees also insisted that an open communication channel between all the stakeholders involved in the project from the early phase of the project should reduce the inefficiencies in the project activities.

In the third section, when researcher asked about the factors which are not identified in this question sheets, the interviewees' responses indicated improper communication between various stakeholders from early stages of projects, improper planning, non-performance of vendors and delays in government permits as few prominent factors.

Almost all the interviewees were well versed about several of the project contracting types and have worked personally for several such projects, however the IPD was new. It was observed that across the age group all the interviewees were open to adapt to IPD at a technical level, though they were uncertain on the contractual, commercial or legal implications of IPD as against the traditional project deliveries. The interviewees were asked about the IPD and the framework; the majority had no have experience with the IPD approach and tried again to link it to another execution strategy, similar to partnering and alliancing. Also the interviewees were interested to know how to apply the IPD and how it is possible to bring the bidders contractor into the design early before the award. The other understanding and fear was that if the contractor participation at the design could influence his ideas, technology or selection strategy this will complicate the participation.

Bidding contractors participation to review the design documents and to ensure no vagueness in these deliverables was very interesting subject and approach to the interviewees. Interviewees agreed that Participation by one bidding contractor members or by several should have the same objective by improving the design quality and making the scope much clear for bidding purposes. Also interviewees have requested if possible to improve the framework by covering other factors not mentioned in the list since participant might come with new problems and lessons. All interviewees were finding it difficult to bring the bidding contractor as early as in the design and it will be difficult to draw their attention that early, however some of the interviewees also mentioned that having one representative from each contractor and other stakeholders could be enough to carry and cascade majority of the poor performance factors. The emphasis was that if the contractor reviews the design document, he would easily discover the shortfalls and gaps, which will allow the designer to correct and improve. Also one of the interviewees requested to change the stakeholder from the EPC contractor to EPC bidders, where more than one contractor is participating at the bidding, and then the framework can add one more stakeholder as the awarded contractor. The duration was also debatable by the interviewees, since it varies between each project and was proposed to be more flexible and longer to cover different times, i.e. it was proposed to avoid having the number of months and enough to mention the phase, such as FEED, design, procure and construct.

All the interviewees were interested to implement the conceptual framework and were interested to understand the impact of various stakeholders participation in the same time and place, which might extend the design phase as highlighted by several interviewees. The framework also could be improved upon implementation and various stakeholders could participate. Interviewees also suggested different implementation approaches, such as inviting different engineers from each bidders rather than bring all the bidders engineers (i.e. bring mechanical from bidder A and bring civil from bidders B and so on). Another interviewee also suggested to send the design document to the bidders while they are at their home offices rather than bringing them at the design office. There was another suggestion that we can gather all the bidders along with other stakeholders at several workshops and meetings to discuss various technical approaches (such as, plant review workshop, design review workshop, HAZOP workshop, contractibility workshop, HSE workshop and so on).

In chapter (6) next, the researcher will apply the Interpretive Structural Modelling (ISM) approach to identify the relationship between the mentioned poor performance factors and which factors play as driving force, dependent and which factors are linking with other factors.

Chapter 6. INTERPRETIVE STRUCTURAL MODELLING (ISM) APPROACH

Interpretive structural modelling (ISM) is an established methodology to identify relationships between specific topics and items, in order to define a problem or issue. This approach has been widely used by various researchers to represent the inter-relationships between various elements related to the same problem and topic. It is generally noticed that researchers face difficulties in handling and dealing with complex problems or issues. The complexity of these problems and issues is because of the presence of a large number of elements/factors and interactions between them. The presence of directly or indirectly related factors complicates the structure of the framework which may or may not be articulated in a clear style. It becomes difficult to process such a framework in which structure is not clearly defined. Hence, it requires the development of a methodology which helps in recognizing a structure within the framework. Interpretive structural modelling (ISM) is such a methodology, (Ravi V. and Shankar R., 2005). ISM is defined as a process aimed at assisting the researcher to well understand what he believes and to recognize clearly what he does not know. Its most important function is organisational. The information added (by the process) is zero (Farris D.R. and Sage A.P.,1975). The value added is structural. The ISM process converts uncertain, poorly expressed intellectual models of systems into visible and well-defined models (Raj T., Shankar R. and Suhaib M., 2007; Sage A.P., 1977; Singh M.D., Shankar R., Narain R. and Agarwal A., 2003; Raj T. and Attri R., 2011).

ISM is an interactive learning process. In this technique, a set of different directly and indirectly related elements are structured into a comprehensive systematic model, (Ravi V. and Shankar R., 2005). The model so formed portrays the structure of a complex issue or problem in a carefully designed pattern implying graphics as well as words (Sage A.P.,1977; Warfield J.W., 1974; Ravi V. and Shankar R., 2005; Singh M.D., Shankar R., Narain R. and Agarwal A., 2003). Interpretive structural modelling (ISM) is a well-established methodology for identifying relationships among specific items, which define a problem or an issue (Agarwal A., Shankar R. and Tiwari, M.K., 2006). For any complex problem under consideration, a number of factors may be related to an issue or problem. However, the direct and indirect relationships between the factors describe the situation far more accurately than the individual factor taken into isolation. Therefore, ISM develops insights into collective understandings of these relationships, (Sage A.P., 1977; Warfield J.W., 1974; Ravi V. and Shankar R., 2005; Singh M.D., Shankar R., Narain R. and Agarwal A., 2003). ISM starts with an identification of the variables – in this research the factors related to poor performance of Oil & Gas projects, which are relevant to schedule delay or cost impact – and then encompasses them within a group problem-solving technique. Then a contextually relevant subordinate relation is chosen. Having decided on the element set and the contextual relation, a structural self-interaction matrix (SSIM) is developed based on pairwise comparison of variables. In the next step, the SSIM is converted into a reachability matrix (RM) and its transitivity is checked. Once transitivity embedding is complete, a matrix model is obtained. Then, the partitioning of the elements and an extraction of the structural model called ISM is derived, (Jharkharia S. and Shankar R., 2005; Agarwal A., Shankar R. and Tiwari, M.K., 2006). Accordingly, a methodical application of some basic concepts of graph theory is used in a way that theoretical, conceptual and computational control are broken to explain the complex pattern of contextual relationship between set of factors. ISM is intended to be applied to utilise systematic and logical thinking to structure the factors and identify the relationship between them (Ravi V., Shankar R. and Tiwari M.K., 2005).

ISM methodology is interpretive as the judgment of Oil & Gas experts decides whether and how different factors are related. It is structural on the basis of a shared relationship; an overall structure is extracted from the complex set of factors. It is a modelling technique, as the specific relationships and overall structure are shown in a digraph model. It helps to impose order and direction on the complexity of relationships between the poor performance factor, (Jharkharia S. and Shankar R., 2005; Agarwal A., Shankar R. and Tiwari, M.K., 2006).

ISM methodology Steps: Warfield developed a methodology that uses systematic application of some basic designs of graph theory and Boolean algebra in such a way that when implemented in a man machine interactive mode, theoretical, conceptual and computational leverage is exploited to construct directed graph (a representation of the hierarchical structure of the system), (Warfield J.W., 1974). This methodology has at least two desirable properties when compared to the similar approaches, namely ease in the sense of not requiring from the user i.e. viewpoint of advance mathematical knowledge and efficiency in terms of economizing in computer time (Warfield J.W., 1974). The steps involved in ISM modelling are as follows: 1) Identify the factors which are relevant to the poor performance. This will be done by utilising the literature data and the validation by the interviewees. 2) Establish a contextual relationship between the factors with respect to which pairs of factors would be studied. 3) Develop a structural self-interaction matrix (SSIM) of factors. This matrix should show the pair-wise relationship between factors of the framework. This matrix is checked for transitivity. 4) Develop a reachability matrix from the SSIM. 5) Partition the reachability matrix into different levels. 6) Convert the reachability matrix into lessened form. 7) Draw digraph based on the relationship given in reachability matrix and remove transitive links. 8) Convert the subsequent digraph into an ISM- based model by replacing factor nodes with the statements. 9) Review the model to check for conceptual inconsistency and make the necessary modifications. Below these steps are laid out in more detail:

6.1 Step 1: Structural Self-Interaction Matrix (SSIM)

ISM methodology suggests the use of expert opinions based on various management techniques such as brain storming, interview, nominal group technique, etc. in developing the contextual relationship among the variables, (Agarwal A., Shankar R. and Tiwari, M.K., 2006; Ravi V., Shankar R. and Tiwari M.K., 2005; Watson R., 1978)

In this work, the researcher will consider the poor performance factors identified from the literature and validated by the interviewees. This will help in identifying the nature of the contextual relationship between the factors.

The researcher opted to develop the Structural Self-Interaction Matrix using two experts rather than one, to help emphasise the nature of and the relationship between the variables (factors). Ensuring that the factor relations are agreed by two experts should give it a more solid interaction basis. These two should be among the interviewees, and familiar with Oil & Gas problems. In the end, the experts selected for the question piloting work were chosen to build the SSIM matrix because of their deep knowledge of the factors and variables, demonstrated during the piloting exercise.

To analyse the factors, a contextual relationship of 'leads to' or 'influences' type will be opted/selected by the interviewee. This means that one poor performance factor influences another poor performance factor. Accordingly, a contextual relationship between the identified poor performance factors will be developed. It is worth mentioning that in the contextual relationship for each poor performance factor and the existence of a relationship between any two factors (1 and 2), the associated direction of the relationship is examined. The following four codes are used to represent the direction of relationship between every two poor performance factors (such as 1 and 2): (1) "V" code will be used for the relation from factor 1 to factor 2 (i.e., factor 1 will influence factor 2). (2) "A" code will be used for the relation from poor performance factor 2 to poor performance factor 1 (i.e., factor 1 will be influenced by factor 2) (3) "X" code will be used for both direction relations (i.e. factors 1 and 2 will influence each other) (4) "O" code will be used for no relation between the factors (i.e., barriers 1 and 2 are unrelated). Based on the contextual relationships, the SSIM is plotted. The result is plotted in the below table with 28 poor performance factors.

The above Structural Self-Interaction Matrix was developed based on ISM methodology, where the researcher had developed the contextual relationship among the poor performance factors by utilizing two references to develop the matrix; his experience and one of the interviewee, as a result the matrix was developed by the above described four codes.

6.2 Step 2: Reachability Matrix

The next step in the ISM approach is to develop an initial reachability matrix from the previously developed matrix. SSIM is changed/converted into the initial reachability matrix by replacing the four codes (i.e., V, A, X or O) of SSIM with 1s or 0s in the initial reachability matrix. The guidelines for replacement should be: (1) If the (1, 2) entry in the SSIM is "V" code, then the (1, 2) entry in the reachability matrix will be 1 and the (2,1) entry becomes 0. (2) If the (1, 2) entry in the SSIM is "A" code, then the (1, 2) entry in the matrix becomes 0 and the (2,1) entry becomes 1. (3) If the (1, 2) entry in the SSIM is "X" code, then the (1,2) entry in the matrix becomes 1 and the (2,1) entry also becomes 1. (4) If the (1, 2) entry in the SSIM is O, then the (1, 2) entry in the matrix becomes 0 and the (2,1) entry also becomes 0. Applying these guidelines, the initial reachability matrix is prepared. Then 1* entries are included to incorporate transitivity to fill the gap, if any, in the factor collected during development of structural self-instructional matrix. After applying the transitivity concept as explained above, the final reachability matrix is developed as per the below table.

The above initial reachability matrix was developed from previously developed Structural Self-Interaction Matrix (SSIM) by replacing SSIM four codes to a binary numbers (i.e., V, A, X or O) of SSIM with 1s or 0s in the initial reachability matrix. This was developed by replacing all factors with (1) If the (first factor, and second factor) entry in the SSIM has code "V", then the (first factor, second factor) entry in the reachability matrix replaced to 1 and the (second, first) entry replaced with 0. Where If the (first, second) factors in the SSIM was "A" code, then the (first, second) factors in the matrix replaced with 0 and the (second, first) factors replaced with 1. Continuing If the (fist, second) factors in the SSIM was "X" code, then the (first, second) factors in the matrix replaced with 1 and the (second,1first) factors also replaced with 1. Last step If the (first, second) factors in the SSIM was O, then the (first, second) factors in the matrix replaced with 0 and the (second, first) factors also replaced with 0. Applying these guidelines, the initial reachability matrix developed as above.

Sr. No	Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	Lack of effective Project Management, Inadequate experience of project team from all parties.		O	X	V	A	X	A	A	V	X	V	X	V	V	A	V	V	V	A	V	O	V	V	X	V	O	V	X	V	A	V	V	A	A	V	A	X	V
2	Insufficient team building during design and EPC	O		O	O	A	A	V	O	O	O	O	V	O	O	O	O	O	V	O	O	O	O	O	O	V	O	O	A	O	V	O	O	A	O	O	O	X	O
3	Inappropriate overall organization structure linking all project teams.	X	O		V	A	A	V	O	O	O	O	V	V	O	A	O	V	O	O	O	O	O	V	V	V	O	O	A	V	A	V	O	V	O	O	A	X	V
4	Conflicts / Disputes between Owner stakeholders (Project team and Operations).	V	O	V		A	A	A	A	A	X	A	O	A	A	A	O	A	A	A	A	A	A	X	X	A	A	O	A	X	A	X	A	V	A	A	A	X	A
5	Project Manager does not have full authority	A	A	A	A		V	O	A	V	A	O	O	A	O	O	O	O	O	O	O	O	V	V	V	V	O	O	A	V	A	V	O	V	A	O	A	O	V
6	Insufficient & inexperienced management personnel from Owner.	X	A	A	A	V		V	V	V	V	V	X	V	V	V	O	V	V	O	V	V	V	V	V	V	V	V	V	V	O	V	O	V	V	V	O	O	V
7	Frequent Owner Interference.	A	V	V	A	O	V		A	X	O	A	A	O	O	O	O	V	O	A	V	A	V	V	O	A	O	O	A	V	O	V	V	O	A	V	O	O	O
8	Excessive Bureaucracy in Owner's organization.	A	O	O	A	A	V	A		V	V	O	V	O	O	O	O	O	V	O	V	O	V	O	V	X	O	O	V	V	O	V	O	V	V	V	O	V	O
9	Issues regarding permissions/ approvals from other stakeholders.	V	O	O	A	V	V	X	V		X	O	X	A	O	A	O	X	A	A	V	X	V	X	A	A	O	V	A	V	A	V	V	X	A	O	O	A	O
10	Slow decision making & Lack of staff involvement from Owner side.	X	O	O	X	A	V	O	V	X		A	A	V	V	A	O	V	X	A	V	V	V	V	V	A	V	O	A	V	O	V	V	A	A	V	O	A	V
11	Lack of IT use in communication and information Management.	V	O	O	A	O	V	A	O	O	A		A	O	V	A	V	V	O	O	V	O	O	V	V	V	V	X	A	V	O	V	V	O	O	V	A	O	V
12	Lack of mechanism for recording, analyzing, and transferring project lessons learned.	X	V	V	O	O	X	A	V	X	A	A		O	V	A	V	X	A	O	V	V	V	X	X	A	V	X	X	V	O	V	V	A	V	V	O	O	O
13	Inadequate control procedures from owner side to monitor the progress and delay.	V	O	V	A	A	V	O	O	A	V	O	O		O	A	O	V	V	A	V	A	V	V	V	X	O	A	A	V	O	V	O	X	O	V	O	A	V
14	Incomplete or inaccurate cost estimate by owner & EPC Contractors.	V	O	O	A	O	V	O	O	O	V	V	V	O		A	A	O	A	A	A	A	A	A	A	A	A	A	A	V	A	V	V	X	O	A	A	O	V
15	Inadequate or improper Planning from Owner to deliver the project.	A	O	A	A	O	V	O	O	A	A	A	A	A	A		O	V	X	X	V	A	V	O	V	V	O	O	O	V	O	V	O	X	O	V	O	O	V
16	Poor estimation of labor productivity by EPC.	V	O	O	O	O	O	O	O	O	O	V	V	O	A	O		O	O	A	A	O	O	A	A	O	O	O	O	O	A	O	V	X	O	A	A	O	O
17	Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor	V	O	V	A	O	V	V	O	X	V	V	X	V	O	V	O		A	A	A	A	A	X	A	A	A	A	A	O	O	V	O	A	A	O	O	A	O
18	Lack of Client Participation in Major Milestones during Design.	V	V	O	A	O	V	O	V	A	X	O	A	V	A	X	O	A		V	V	V	V	V	V	X	V	V	V	O	O	V	O	V	O	O	O	O	O
19	Mega size, Design complexity and complications.	A	O	O	A	O	O	A	O	A	A	O	O	A	A	X	A	A	V		V	X	X	X	A	A	V	A	V	V	A	V	V	O	O	V	X	O	O
20	Design Variations or changes in client requirement.	V	O	O	A	O	V	V	V	V	V	V	V	V	A	V	A	A	V	V		A	A	X	A	A	A	O	A	V	O	V	V	O	O	X	O	A	A
21	Inadequate project Objective and scope definition by Owner and FEED designer.	O	O	O	A	O	V	A	O	X	V	O	V	A	A	A	O	A	V	X	A		X	V	A	A	V	O	V	V	O	O	V	O	O	O	O	O	V
22	Lack of Engineering clear roles/goals.	V	O	O	A	V	V	V	V	V	V	O	V	V	A	V	O	A	V	X	A	X		V	A	A	X	O	V	V	O	O	O	A	O	O	O	O	O
23	Poor quality of deliverables by FEED Designer	V	O	V	X	V	V	V	O	X	V	V	X	V	A	O	A	X	V	X	X	V	V		A	A	X	A	A	V	A	V	V	A	V	V	O	O	V
24	Delayed or insufficient design information from owner.	X	O	V	X	V	V	O	V	A	V	V	X	V	A	V	A	A	V	A	A	A	A	A		A	V	O	A	V	O	V	V	O	V	V	O	A	V
25	Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance).	V	V	V	A	V	V	A	X	A	A	V	A	X	A	V	O	A	X	A	A	A	A	A	A		V	V	A	V	O	O	O	A	O	O	O	O	V
26	Inconsistency between specification, prevailing international standards and owner's procedures / Specifications.	O	O	O	A	O	V	O	O	O	V	V	V	O	A	O	O	A	V	V	A	V	X	X	V	V		A	O	V	O	V	V	O	O	O	O	O	V
27	Outdated design Software.	V	O	O	O	O	V	O	O	V	O	X	X	A	A	O	O	A	V	A	O	O	O	A	O	V	A		O	O	O	O	O	O	O	O	O	O	O
28	Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding.	X	A	A	A	A	V	A	V	A	A	A	X	A	A	O	O	A	V	V	A	V	V	A	A	A	O	O		V	V	V	V	O	O	X	O	O	V
29	Delay in Tendering and award schedule.	V	O	V	X	V	V	V	V	V	V	V	V	V	V	V	O	O	O	V	V	V	V	V	V	V	V	O	V		A	V	O	O	A	A	A	O	V
30	Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors.	A	V	A	A	A	O	O	O	A	O	O	O	O	A	O	A	O	O	A	O	O	O	A	O	O	O	O	V	A		V	V	V	V	A	V	O	A
31	Delay in procurement by Contractor.	V	O	V	X	V	V	V	V	V	V	V	V	V	V	V	O	V	V	V	V	O	O	V	V	O	V	O	V	V	V		A	X	A	A	A	O	A
32	Financial issues of Contractor during execution.	V	O	O	A	O	O	V	O	V	V	V	V	O	V	O	V	O	O	V	V	V	O	V	V	O	V	O	V	O	V	A		V	O	A	X	O	A
33	Delay in mobilization during Design & EPC.	A	A	V	V	V	V	O	V	X	A	O	A	X	X	X	X	A	V	O	O	O	A	A	O	A	O	O	O	O	V	X	V		O	O	A	O	O
34	Flexibility of Client to adopt technical changes	A	O	O	A	A	V	A	V	A	A	O	V	O	O	O	O	A	O	O	O	O	O	V	V	O	O	O	O	A	V	A	O	O		V	O	V	X
35	Less time for EPC tendering & too many bidders	V	O	O	A	O	V	V	V	O	V	V	V	V	A	V	A	O	O	V	X	O	O	V	V	O	O	O	X	A	A	A	A	O	V		O	O	V
36	Limited capability of Contractor	A	O	A	A	A	O	O	O	O	O	A	O	O	A	O	A	O	O	X	O	O	O	O	O	O	O	O	O	A	V	A	X	A	O	O		O	A
37	Limited authority of PMC Consultant	X	X	X	X	O	O	O	V	A	A	O	O	A	O	O	O	A	O	O	A	O	O	O	A	O	O	O	O	O	O	O	O	O	V	O	O		V
38	Poor Technical decision during tendering by PMC	V	O	V	A	V	V	O	O	O	V	V	O	V	V	V	O	O	O	O	A	V	O	V	V	V	V	O	V	V	A	A	A	O	X	V	A	V	

Figure (6.1) Full Matrix

Sr. No	Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	Lack of effective Project Management, Inadequate experience of project team from all parties.		0	1	1	0	1	0	0	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	1	0	1	1	0	0	1	0	1	1
2	Insufficient team building during design and EPC	0		0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0
3	Inappropriate overall organization structure linking all project teams.	1	0		1	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	1	1
4	Conflicts / Disputes between Owner stakeholders (Project team and Operations).	0	0	0		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0
5	Project Manager does not have full authority	1	1	1	1		1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1	0	1	0	1	0	0	0	0	1
6	Insufficient & inexperienced management personnel from Owner.	1	1	1	1	0		1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	0	1
7	Frequent Owner Interference.	1	0	0	1	0	0		0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0
8	Excessive Bureaucracy in Owner's organization.	1	0	0	1	1	0	1		1	1	0	1	0	0	0	0	0	1	0	1	0	1	0	1	1	0	0	1	1	0	1	0	1	1	1	0	1	0
9	Issues regarding permissions/ approvals from other stakeholders.	0	0	0	1	0	0	1	0		1	0	1	0	0	0	0	1	0	0	1	1	1	1	0	0	0	1	0	1	0	1	1	1	0	0	0	0	0
10	Slow decision making & Lack of staff involvement from Owner side.	1	0	0	1	1	0	0	0	1		0	0	1	1	0	0	1	1	0	1	1	1	1	1	0	1	0	0	1	0	1	1	0	0	1	0	0	1
11	Lack of IT use in communication and information Management.	0	0	0	1	0	0	1	0	0	1		0	0	1	0	1	1	0	0	1	0	0	1	1	1	1	1	0	1	0	1	1	0	0	1	0	0	1
12	Lack of mechanism for recording, analyzing, and transferring project lessons learned.	1	0	0	0	0	1	1	0	1	1	1		0	1	0	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	1	1	0	1	1	0	0	0
13	Inadequate control procedures from owner side to monitor the progress and delay.	0	0	0	1	1	0	0	0	1	0	0	0		0	0	0	1	1	0	1	0	1	1	1	1	0	0	0	1	0	1	0	1	0	1	0	0	1
14	Incomplete or inaccurate cost estimate by owner & EPC Contractors.	0	0	0	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1
15	Inadequate or improper Planning from Owner to deliver the project.	1	0	1	1	0	0	0	0	1	1	1	1	1	1		0	1	1	1	1	0	1	0	1	1	0	0	0	1	0	1	0	1	0	1	0	0	1
16	Poor estimation of labor productivity by EPC.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
17	Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0		0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
18	Lack of Client Participation in Major Milestones during Design.	0	0	0	1	0	0	0	0	1	1	0	1	0	1	1	0	1		1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0
19	Mega size, Design complexity and complications.	1	0	0	1	0	0	1	0	1	1	0	0	1	1	1	1	1	0		1	1	1	1	0	0	1	0	1	1	0	1	1	0	0	1	1	0	0
20	Design Variations or changes in client requirement.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0		0	0	1	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0
21	Inadequate project Objective and scope definition by Owner and FEED designer.	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	0	1	1		1	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1
22	Lack of Engineering clear roles/goals.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1		1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
23	Poor quality of deliverables by FEED Designer	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	1	1	0	1	1	0	0		0	0	1	0	0	1	0	1	1	0	1	1	0	0	1
24	Delayed or insufficient design information from owner.	1	0	0	1	0	0	0	0	1	0	0	1	0	1	0	1	1	0	1	1	1	1	1		0	1	0	0	1	0	1	1	0	1	1	0	0	1
25	Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance).	0	0	0	1	0	0	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1		1	1	0	1	0	0	0	0	0	0	0	0	1
26	Inconsistency between specification, prevailing international standards and owner's procedures / Specifications.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	1	0	0		0	0	1	0	1	1	0	0	0	0	0	1
27	Outdated design Software.	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	1	0	0	0	1	0	0	1		0	0	0	0	0	0	0	0	0	0	0
28	Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding.	1	1	1	1	1	0	1	0	1	1	1	1	1	1	0	0	1	0	0	1	0	0	1	1	1	0	0		1	1	1	1	0	0	1	0	0	1
29	Delay in Tendering and award schedule.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1	0	0	0	0	0	0	1
30	Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors.	1	0	1	1	1	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1		1	1	1	1	0	1	0	0
31	Delay in procurement by Contractor.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		0	1	0	0	0	0	0
32	Financial issues of Contractor during execution.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1		1	0	0	1	0	0
33	Delay in mobilization during Design & EPC.	1	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0		0	0	0	0	0
34	Flexibility of Client to adopt technical changes	1	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0		1	0	1	1
35	Less time for EPC tendering & too many bidders	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	0	0		0	0	1
36	Limited capability of Contractor	1	0	1	1	1	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0		0	0
37	Limited authority of PMC Consultant	1	1	1	1	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		1
38	Poor Technical decision during tendering by PMC	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0	

Figure (6.2) Initial Reachability Matrix

Sr. No	Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Drivers
1	Lack of effective Project Management, Inadequate experience of project team from all parties.		0	1	1	0	1	0	0	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	1	1*	1	1	0	0	1	0	1	1	26
2	Insufficient team building during design and EPC	0		0	0	0	0	1	0	0	0	0	1	1*	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1*	0	0	0	0	0	1	1*	9
3	Inappropriate overall organization structure linking all project teams.	1	0		1	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0	1	1	14
4	Conflicts / Disputes between Owner stakeholders (Project team and Operations).	0	0	0		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1*	0	0	0	1	0	1	0	1	0	0	0	1	1*	9
5	Project Manager does not have full authority	1	1	1	1		1	1*	0	1	1*	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1*	0	0	1	0	1	0	1	1*	0	0	0	1	18
6	Insufficient & inexperienced management personnel from Owner.	1	1	1	1	0		1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1*	1	1	1	0	0	1	31
7	Frequent Owner Interference.	1	0	0	1	1*	0		0	1	1*	0	0	0	0	0	0	1	1*	0	1	0	1	1	1*	0	0	0	0	1	0	1	1	1*	0	1	0	0	0	16
8	Excessive Bureaucracy in Owner's organization.	1	0	0	1	1	0	1		1	1	0	1	0	0	0	0	0	1	0	1	1*	1	1*	1	1	0	0	1	1	0	1	1*	1	1	1	0	1	0	22
9	Issues regarding permissions/ approvals from other stakeholders.	0	0	0	1	1*	0	1	0		1	0	1	1*	0	0	0	1	1*	0	1	1	1	1	1*	0	0	1	0	1	0	1	1	1	0	0	0	0	0	18
10	Slow decision making & Lack of staff involvement from Owner side.	1	0	0	1	1	0	0	0	1		0	0	1	1	0	0	1	1	0	1	1	1	1	1	1*	1	1*	0	1	0	1	1	0	0	1	0	0	1	21
11	Lack of IT use in communication and information Management.	0	0	0	1	0	0	1	0	0	1		0	0	1	0	1	1	0	0	1	1*	0	1	1	1	1	1	1*	1	0	1	1	0	0	1	0	0	1	19
12	Lack of mechanism for recording, analyzing, and transferring project lessons learned.	1	0	0	0	0	1	1	0	1	1	1		0	1	0	1	1	1*	0	1	1	1	1	1	1*	1	1	1	1	0	1	1	1*	1	1	0	0	0	25
13	Inadequate control procedures from owner side to monitor the progress and delay.	0	0	0	1	1	0	0	0	1	0	0	0		0	0	0	1	1	0	1	0	1	1	1	1	0	0	0	1	0	1	1*	1	0	1	0	0	1	16
14	Incomplete or inaccurate cost estimate by owner & EPC Contractors.	0	0	0	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1	6
15	Inadequate or improper Planning from Owner to deliver the project.	1	0	1	1	0	0	0	0	1	1	1	1	1	1		0	1	1	1	1	0	1	0	1	1	0	0	0	1	0	1	1*	1	0	1	0	0	1	22
16	Poor estimation of labor productivity by EPC.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	3
17	Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor	0	0	0	1	0	0	0	0	1	1*	0	1	0	0	0	0		0	0	0	0	0	1	1*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7
18	Lack of Client Participation in Major Milestones during Design.	0	0	0	1	0	0	0	0	1	1	0	1	1*	1	1	1*	1		1	1	1	1	1	1	1	1	1	1	1*	0	1	1*	1	0	0	0	0	0	23
19	Mega size, Design complexity and complications.	1	0	0	1	0	0	1	0	1	1	0	0	1	1	1	1	1	0		1	1	1	1	0	0	1	0	1	1	0	1	1	0	0	1	1	0	0	21
20	Design Variations or changes in client requirement.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1*	1	1	0	0		0	0	1	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	10
21	Inadequate project Objective and scope definition by Owner and FEED designer.	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	0	1	1		1	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	16
22	Lack of Engineering clear roles/goals.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1		1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	10
23	Poor quality of deliverables by FEED Designer	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	1	1	0	1	1	1*	0		0	0	1	0	0	1	0	1	1	0	1	1	0	0	1	16
24	Delayed or insufficient design information from owner.	1	0	0	1	0	0	0	0	1	1*	0	1	1*	1	0	1	1	1*	1	1	1	1	1		0	1	1*	0	1	0	1	1	0	1	1	0	0	1	23
25	Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance).	0	0	0	1	0	0	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	1	1		1	1	0	1	0	0	0	0	0	0	0	0	1	20
26	Inconsistency between specification, prevailing international standards and owner's procedures / Specifications.	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	1	0	0		0	0	1	0	1	1	0	0	0	0	0	1	10
27	Outdated design Software.	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	1	1*	0	0	1	1*	0	1		0	0	0	0	0	0	0	0	0	0	0	10
28	Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding.	1	1	1	1	1	0	1	0	1	1	1	1	1	1	0	0	1	0	0	1	0	0	1	1	1	0	0		1	1	1	1	0	0	1	0	0	1	23
29	Delay in Tendering and award schedule.	0	0	0	1	1*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1	1*	0	0	0	0	0	1	5
30	Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors.	1	0	1	1	1	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	1	1*	0	0	0	0	1		1	1	1	1	0	1	0	0	16
31	Delay in procurement by Contractor.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		0	1	0	0	0	0	0	3
32	Financial issues of Contractor during execution.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1*	0	0	0	0	0	1		1	0	0	1	0	0	6
33	Delay in mobilization during Design & EPC.	1	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	1	1	1*	1	0	0	0	0	0	1	0		0	0	0	0	0	15
34	Flexibility of Client to adopt technical changes	1	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1*	1	1*	0		1	0	1	1	15
35	Less time for EPC tendering & too many bidders	0	0	0	1	1*	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1	1	1	1*	0		0	0	1	13
36	Limited capability of Contractor	1	1*	1	1	1	0	0	0	0	0	1	0	0	1	0	1	1*	0	1	1*	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0		0	0	15
37	Limited authority of PMC Consultant	1	1	1	1	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		1	11
38	Poor Technical decision during tendering by PMC	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0		7
Dependence		16	6	8	32	11	3	13	2	21	19	7	15	16	22	6	12	25	12	10	24	12	17	25	25	16	13	9	10	28	6	31	26	18	8	15	4	6	21	**570**

Figure (6.3) Final Reachability Matrix

From the initial reachability matrix the final reachability matrix is developed by including 1* as transitivity to fill the gap as above.

6.3 Step 3: Level Partitions

From the above final reachability matrix, for each poor performance factor, reachability set and antecedent sets are obtained. The reachability set contains the poor performance factor itself and the other poor performance factor that it may impact, whereas the antecedent set contains the poor performance factor itself and the other factor that may impact it. Thereafter, the intersection of these sets is obtained for all the factors and levels of different factors are decided. The poor performance factors for which the reachability and the intersection sets are the same occupy the top level in the ISM hierarchy. The top-level factors are those factors that will not lead the other factors above their own level in the hierarchy. Once the top-level poor performance factor is identified, it is removed/ deleted from consideration. Then, the same process is repeated to find out the factors in the next level. This process is continued until the level of each factor is found. These levels help in building the diagraph and the ISM model as plotted below.

Variable	Reachability Sets
1	3,4,6,9,10,11,12,13,14,16,18,20,22,23,24,25,27,28,29,30,31,32,35,37,38
2	7,12,13,18,25,30,31,37,38
3	1,4,7,12,13,17,23,24,25,29,31,33,37,38
4	10,23,24,25,29,31,33,37,38
5	1,2,3,4,6,7,9,10,22,23,24,25,26,29,31,33,34,38
6	1,2,3,4,7,8,9,10,11,12,13,14,15,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,34,35,38
7	1,4,5,9,10,17,18,20,22,23,24,29,31,32,33,35
8	1,4,5,7,9,10,12,18,20,21,22,23,24,25,28,29,31,32,33,34,35,37
9	4,5,7,10,12,13,17,18,20,21,22,23,24,27,29,31,32,33
10	1,4,5,9,13,14,17,18,20,21,22,23,24,25,26,27,29,31,32,35,38
11	4,7,10,14,16,17,20,21,23,24,25,26,27,28,29,31,32,35,38
12	1,6,7,9,10,11,14,16,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,34,35
13	4,5,9,17,18,20,22,23,24,25,29,31,32,33,35,38
14	4,29,31,32,33,38
15	1,3,4,9,10,11,12,13,14,17,18,19,20,22,24,25,29,31,32,33,35,38
16	14,32,33
17	4,9,10,12,23,24,31
18	4,9,10,12,13,14,15,16,17,19,20,21,22,23,24,25,26,27,28,29,31,32,33
19	1,4,7,9,10,13,14,15,16,17,20,21,22,23,26,28,29,31,32,35,36
20	4,14,15,16,17,23,29,31,32,35
21	4,7,9,13,14,15,17,19,20,22,23,26,28,29,32,38
22	4,14,17,19,20,21,23,26,28,29
23	4,9,12,14,16,17,19,20,21,26,29,31,32,34,35,38
24	1,4,9,10,12,13,14,16,17,18,19,20,21,22,23,26,27,29,31,32,34,35,38
25	4,7,8,9,10,12,13,14,17,18,19,20,21,22,23,24,26,27,29,38
26	4,14,17,20,22,23,29,31,32,38
27	11,12,13,14,17,19,20,23,24,26
28	1,2,3,4,5,7,9,10,11,12,13,14,17,20,23,24,25,29,30,31,32,35,38
29	4,5,31,32,38
30	1,3,4,5,9,14,16,19,23,24,29,31,32,33,34,36
31	4,24,33
32	4,24,25,31,33,36
33	1,2,9,10,12,13,14,15,16,17,22,23,24,25,31
34	1,4,5,7,9,10,17,24,29,30,31,32,35,37,38
35	4,5,14,16,20,24,28,29,30,31,32,33,38
36	1,2,3,4,5,11,14,16,17,19,20,29,31,32,33
37	1,2,3,4,9,10,13,17,20,24,38
38	4,20,30,31,32,34,36

Table (6.1) Reachability Sets

The above reachability sets are developed from final reachability matrix, for each poor performance factor. This is obtained by listing the poor performance factor itself and the other poor performance factor that it may affect (i.e. which as code 1 in the final Reachability Matrix in each factor row). As a result, the intersection of these sets are decided for all the factors and levels of different factors are decided.

Variable	Antecend Set
1	3,5,6,7,8,10,12,15,19,24,28,30,33,34,36,37
2	5,6,28,33,36,37
3	1,5,6,15,28,30,36,37
4	1,3,5,6,7,8,9,10,11,13,14,15,17,18,19,20,21,22,23,24,25,26,28,29,30,31,32,34,35,36,37,38
5	7,8,9,10,13,28,29,30,34,35,36
6	1,5,12
7	2,3,5,6,8,9,11,12,19,21,25,28,34
8	6,25
9	1,5,6,7,8,10,12,13,15,17,18,19,21,23,24,25,28,30,33,34,37
10	1,4,5,6,7,8,9,11,12,15,17,18,19,24,25,28,33,34,37
11	1,6,12,15,27,28,36
12	1,2,3,6,8,9,15,17,18,23,24,25,27,28,33
13	1,2,3,6,9,10,15,18,19,21,24,25,27,28,33,37
14	1,6,10,11,12,15,16,18,19,20,21,22,23,24,25,26,27,28,30,33,35,36
15	6,18,19,20,21,33
16	1,11,12,18,19,20,23,24,30,33,35,36
17	1,3,6,7,9,10,11,12,13,15,18,19,20,21,22,23,24,25,26,27,28,33,34,36,37
18	1,2,6,7,8,9,10,12,13,15,24,25
19	1,2,6,7,8,9,10,12,13,15,24,25
20	15,18,21,22,23,24,25,30,36
21	1,6,7,8,9,10,11,12,13,15,18,19,21,22,23,24,25,26,27,28,35,36,37,38
22	6,8,9,10,11,12,18,19,22,23,24,25
23	1,5,6,7,8,9,10,12,13,15,18,19,21,24,25,26,33
24	1,3,4,5,6,7,8,9,10,11,12,13,15,17,18,25,27,28,30,31,32,33,34,35,37
25	1,2,3,4,5,6,8,10,11,12,13,15,18,28,32,33
26	5,6,10,11,12,18,19,21,22,23,24,25,27
27	1,6,9,10,11,12,18,24,25
28	1,6,8,11,12,18,19,21,22,35
29	1,3,4,5,6,7,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,25,26,28,30,34,35,36
30	1,2,28,34,35,38
31	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,23,24,26,28,29,30,32,33,34,35,36,38
32	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,21,23,24,26,28,29,30,34,35,36,38
33	3,4,5,6,7,8,9,12,13,14,15,16,18,30,31,32,35,36
34	5,6,8,12,23,24,30,38
35	1,6,7,8,10,11,12,13,15,19,20,23,24,28,34
36	19,30,32,38
37	1,2,3,4,8,34
38	1,2,3,4,5,6,10,11,13,14,15,21,23,24,25,26,28,29,34,35,37

Table (6.2) Antecend Set

The above Antecend sets are developed from final reachability matrix, for each poor performance factor. This is obtained by listing the poor performance factor itself and the other poor performance factor that it may impact it (i.e. which as code 1 in the final Reachability Matrix in each factor column). As a result, the intersection of these sets are decided for all the factors and levels of different factors are decided.

Variables	**Reachability Sets**	**Antecend Set**	**Intersection Set**	**Level**
1	3,4,6,9,10,11,12,13,14,16,18,20,22,23,24,25,27,28,29,30,31,32,35,37,38	3,5,6,7,8,10,12,15,19,24,28,30,33,34,36,37	**3,6,10,12,24,28,30,37**	
2	7,12,13,18,25,30,31,37,38	5,6,28,33,36,37	**37**	
3	1,4,7,12,13,17,23,24,25,29,31,33,37,38	1,5,6,15,28,30,36,37	**1,37**	
4	10,23,24,25,29,31,33,37,38	1,3,5,6,7,8,9,10,11,13,14,15,17,18,19,20,21,22,23,24,25,26,28,29,30,31,32,34,35,36,37,38	**10,23,24,25,29,31,37,38**	
5	1,2,3,4,6,7,9,10,22,23,24,25,26,29,31,33,34,38	7,8,9,10,13,28,29,30,34,35,36	**7,9,10,29,34**	
6	1,2,3,4,7,8,9,10,11,12,13,14,15,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,34,35,38	1,5,12	**1,12**	
7	1,4,5,9,10,17,18,20,22,23,24,29,31,32,33,35	2,3,5,6,8,9,11,12,19,21,25,28,34	**5,9,**	
8	1,4,5,7,9,10,12,18,20,21,22,23,24,25,28,29,31,32,33,34,35,37	6,25	**25**	
9	4,5,7,10,12,13,17,18,20,21,22,23,24,27,29,31,32,33	1,5,6,7,8,10,12,13,15,17,18,19,21,23,24,25,28,30,33,34,37	**5,7,10,12,13,17,18,21,23,24,33**	
10	1,4,5,9,13,14,17,18,20,21,22,23,24,25,26,27,29,31,32,35,38	1,4,5,6,7,8,9,11,12,15,17,18,19,24,25,28,33,34,37	**1,4,5,9,17,18,24,25,**	
11	4,7,10,14,16,17,20,21,23,24,25,26,27,28,29,31,32,35,38	1,6,12,15,27,28,36	**27,28**	
12	1,6,7,9,10,11,14,16,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,34,35	1,2,3,6,8,9,15,17,18,23,24,25,27,28,33	**1,6,9,17,18,23,24,25,27,28,33**	
13	4,5,9,17,18,20,22,23,24,25,29,31,32,33,35,38	1,2,3,6,9,10,15,18,19,21,24,25,27,28,33,37	**9,18,24,25,33**	
14	4,29,31,32,33,38	1,6,10,11,12,15,16,18,19,20,21,22,23,24,25,26,27,28,30,33,35,36	**33**	
15	1,3,4,9,10,11,12,13,14,17,18,19,20,22,24,25,29,31,32,33,35,38	6,18,19,20,21,33	**18,19,20,33**	
16	14,32,33	1,11,12,18,19,20,23,24,30,33,35,36	**33**	
17	4,9,10,12,23,24,31	1,3,6,7,9,10,11,12,13,15,18,19,20,21,22,23,24,25,26,27,28,33,34,36,37	**9,10,12,23,24,**	
18	4,9,10,12,13,14,15,16,17,19,20,21,22,23,24,25,26,27,28,29,31,32,33	1,2,6,7,8,9,10,12,13,15,24,25	**9,10,12,13,15,24,25**	
19	1,4,7,9,10,13,14,15,16,17,20,21,22,23,26,28,29,31,32,35,36	1,2,6,7,8,9,10,12,13,15,24,25	**1,7,9,10,13,15,**	
20	4,14,15,16,17,23,29,31,32,35	15,18,21,22,23,24,25,30,36	**15,23,**	
21	4,7,9,13,14,15,17,19,20,22,23,26,28,29,32,38	1,6,7,8,9,10,11,12,13,15,18,19,21,22,23,24,25,26,27,28,35,36,37,38	**7,9,13,15,19,22,23,26,28,38**	
22	4,14,17,19,20,21,23,26,28,29	6,8,9,10,11,12,18,19,22,23,24,25	**19,23,**	
23	4,9,12,14,16,17,19,20,21,26,29,31,32,34,35,38	1,5,6,7,8,9,10,12,13,15,18,19,21,24,25,26,33	**9,12,19,21,26,**	
24	1,4,9,10,12,13,14,16,17,18,19,20,21,22,23,26,27,29,31,32,34,35,38	1,3,4,5,6,7,8,9,10,11,12,13,15,17,18,25,27,28,30,31,32,33,34,35,37	**1,4,9,10,12,13,17,18,27,31,32,34,35**	
25	4,7,8,9,10,12,13,14,17,18,19,20,21,22,23,24,26,27,29,38	1,2,3,4,5,6,8,10,11,12,13,15,18,28,32,33	**4,8,10,12,13,18,**	
26	4,14,17,20,22,23,29,31,32,38	5,6,10,11,12,18,19,21,22,23,24,25,27	**22,23,**	
27	11,12,13,14,17,19,20,23,24,26	1,6,9,10,11,12,18,24,25	**11,12,24**	
28	1,2,3,4,5,7,9,10,11,12,13,14,17,20,23,24,25,29,30,31,32,35,38	1,6,8,11,12,18,19,21,22,35	**1,11,12,35**	
29	4,5,31,32,38	1,3,4,5,6,7,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,25,26,28,30,34,35,36	**4,5,**	
30	1,3,4,5,9,14,16,19,23,24,29,31,32,33,34,36	1,2,28,34,35,38	**1,34**	
31	4,24,33	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,23,24,26,28,29,30,32,33,34,35,36,38	**4,24,33**	
32	4,24,25,31,33,36	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,21,23,24,26,28,29,30,34,35,36,38	**4,24,36**	
33	1,2,9,10,12,13,14,15,16,17,22,23,24,25,31	3,4,5,6,7,8,9,12,13,14,15,16,18,30,31,32,35,36	**9,12,13,14,15,16,31**	
34	1,4,5,7,9,10,17,24,29,30,31,32,35,37,38	5,6,8,12,23,24,30,38	**5,24,30,38**	
35	4,5,14,16,20,24,28,29,30,31,32,33,38	1,6,7,8,10,11,12,13,15,19,20,23,24,28,34	**20,24,28,**	
36	1,2,3,4,5,11,14,16,17,19,20,29,31,32,33	19,30,32,38	**19,32**	
37	1,2,3,4,9,10,13,17,20,24,38	1,2,3,4,8,34	**1,2,3,4,**	
38	4,20,30,31,32,34,36	1,2,3,4,5,6,10,11,13,14,15,21,23,24,25,26,28,29,34,35,37	**4,34**	

Table (6.3) Level of Variables

The level of Variables was developed by obtaining the intersection of these sets for all the factors and levels of different factors are decided. The poor performance factors for which the reachability and the intersection sets were the same occupied the top level in the ISM hierarchy. The top-level factors were those factors that did not lead the other factors above their own level in the hierarchy. Once the top-level poor performance factors were identified, they were removed/ deleted from consideration. Then, the same process was repeated to find out the factors in the next level. This process was continued until the level of each factor is found. These levels help in building the diagraph and the ISM model as plotted below.

Variables	No of Times
1	16
2	6
3	8
4	32
5	11
6	3
7	13
8	2
9	21
10	19
11	7
12	14
13	15
14	22
15	6
16	11
17	24
18	12
19	10
20	23
21	12
22	17
23	25
24	25
25	16
26	13
27	9
28	10
29	28
30	6
31	31
32	26
33	18
34	8
35	15
36	4
37	6
38	21

Table (6.4) Variables No of Times

The Variable no of times were listed to identify the levels. i.e. top-level factors were those factors that did not lead the other factors above their own level in the hierarchy.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	3,6,9,10,11,12,13,14,16,18,20,22,23,24,25,27,28,29,30,31,32,35,37,38	3,5,6,7,8,10,12,15,19,24,28,30,33,36,37	**3,6,10,12,24,28,30,37**	
2	7,12,13,18,25,30,31,37,38	5,6,28,33,36,37	**37**	
3	1,7,12,13,17,23,24,25,29,31,33,37,38	1,5,6,15,28,30,36,37	**1,37**	
4	10,23,24,25,29,31,33,37,38	1,3,5,6,7,8,9,10,11,13,14,15,17,18,19,20,21,22,23,24,25,26,28,29,30,31,32,35,36,37,38	**10,23,24,25,29,31,37,38**	
5	1,2,3,6,7,9,10,22,23,24,25,26,29,31,33,38	7,8,9,10,13,28,29,30,35,36	**7,9,10,29**	
6	1,2,3,7,8,9,10,11,12,13,14,15,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,35,38	1,5,12	**1,12**	
7	1,5,9,10,17,18,20,22,23,24,29,31,32,33,35	2,3,5,6,8,9,11,12,19,21,25,28	**5,9,**	
8	1,5,7,9,10,12,18,20,21,22,23,24,25,28,29,31,32,33,35,37	6,25	**25**	
9	5,7,10,12,13,17,18,20,21,22,23,24,27,29,31,32,33	1,5,6,7,8,10,12,13,15,17,18,19,21,23,24,25,28,30,33,37	**5,7,10,12,13,17,18,21,23,24,33**	
10	1,5,9,13,14,17,18,20,21,22,23,24,25,26,27,29,31,32,35,38	1,5,6,7,8,9,11,12,15,17,18,19,24,25,28,33,37	**1,5,9,17,18,24,25,**	
11	7,10,14,16,17,20,21,23,24,25,26,27,28,29,31,32,35,38	1,6,12,15,27,28,36	**27,28**	
12	1,6,7,9,10,11,14,16,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,35	1,2,3,6,8,9,15,17,18,23,24,25,27,28,33	**1,6,9,17,18,23,24,25,27,28,33**	
13	5,9,17,18,20,22,23,24,25,29,31,32,33,35,38	1,2,3,6,9,10,15,18,19,21,24,25,27,28,33,37	**9,18,24,25,33**	
14	29,31,32,33,38	1,6,10,11,12,15,16,18,19,20,21,22,23,24,25,26,27,28,30,33,35,36	**33**	
15	1,3,9,10,11,12,13,14,17,18,19,20,22,24,25,29,31,32,33,35,38	6,18,19,20,21,33	**18,19,20,33**	
16	14,32,33	1,11,12,18,19,20,23,24,30,33,35,36	**33**	
17	9,10,12,23,24,31	1,3,6,7,9,10,11,12,13,15,18,19,20,21,22,23,24,25,26,27,28,33,36,37	**9,10,12,23,24,**	
18	9,10,12,13,14,15,16,17,19,20,21,22,23,24,25,26,27,28,29,31,32,33	1,2,6,7,8,9,10,12,13,15,24,25	**9,10,12,13,15,24,25**	
19	1,7,9,10,13,14,15,16,17,20,21,22,23,26,28,29,31,32,35,36	1,2,6,7,8,9,10,12,13,15,24,25	**1,7,9,10,13,15,**	
20	14,15,16,17,23,29,31,32,35	15,18,21,22,23,24,25,30,36	**15,23,**	
21	7,9,13,14,15,17,19,20,22,23,26,28,29,32,38	1,6,7,8,9,10,11,12,13,15,18,19,21,22,23,24,25,26,27,28,35,36,37,38	**7,9,13,15,19,22,23,26,28,38**	
22	14,17,19,20,21,23,26,28,29	6,8,9,10,11,12,18,19,22,23,24,25	**19,23,**	
23	9,12,14,16,17,19,20,21,26,29,31,32,35,38	1,5,6,7,8,9,10,12,13,15,18,19,21,24,25,26,33	**9,12,19,21,26,**	
24	1,9,10,12,13,14,16,17,18,19,20,21,22,23,26,27,29,31,32,35,38	1,3,5,6,7,8,9,10,11,12,13,15,17,18,25,27,28,30,31,32,33,35,37	**1,9,1012,13,17,18,27,31,32,35**	
25	7,8,9,10,12,13,14,17,18,19,20,21,22,23,24,26,27,29,38	1,2,3,5,6,8,10,11,12,13,15,18,28,32,33	**8,10,12,13,18,**	
26	14,17,20,22,23,29,31,32,38	5,6,10,11,12,18,19,21,22,23,24,25,27	**22,23**	
27	11,12,13,14,17,19,20,23,24,26	1,6,9,10,11,12,18,24,25	**11,12,24**	
28	1,2,3,5,7,9,10,11,12,13,14,17,20,23,24,25,29,30,31,32,35,38	1,6,8,11,12,18,19,21,22,35	**1,11,12,35**	
29	5,31,32,38	1,3,5,6,7,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,25,26,28,30,35,36	**5**	
30	1,3,5,9,14,16,19,23,24,29,31,32,33,36	1,2,28,35,38	**1**	
31	24,33	1,2,3,5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,23,24,26,28,29,30,32,33,35,36,38	**24,33**	
32	24,25,31,33,36	1,2,3,5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,21,23,24,26,28,29,30,35,36,38	**24,36**	
33	1,2,9,10,12,13,14,15,16,17,22,23,24,25,31	3,5,6,7,8,9,12,13,14,15,16,18,30,31,32,35,36	**9,12,13,14,15,16,31**	
34	1,5,7,9,10,17,24,29,30,31,32,35,37,38	5,6,8,12,23,24,30,38	**5,24,30,38**	
35	5,14,16,20,24,28,29,30,31,32,33,38	1,6,7,8,10,11,12,13,15,19,20,23,24,28	**20,24,28,**	
36	1,2,3,5,11,14,16,17,19,20,29,31,32,33	19,30,32,38	**19,32**	
37	1,2,3,9,10,13,17,20,24,38	1,2,3,8,	**1,2,3**	

Table (6.5) Level of Variables – Level I

Level I was developed once the top-level poor performance factors were listed in the previous table, they were removed/ deleted from consideration. i.e. Factor 4 (Conflicts/disputes between stakeholders (owner, project team and operations) and Factor 34 (Flexibility of client to adopt technical changes) were removed from the tables. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,9,10,11,12,13,14,16,18,20,22,23,24,25,27,28,29,30,31,32,35,37,38	5,6,7,8,10,12,15,19,24,28,30,33,36,37	**6,10,12,24,28,30,37**	
2	7,12,13,18,25,30,31,37,38	5,6,28,33,36,37	**37**	
3	7,12,13,17,23,24,25,29,31,33,37,38	5,6,15,28,30,36,37	**37**	
4	10,23,24,25,29,31,33,37,38	5,6,7,8,9,10,11,13,14,15,17,18,19,20,21,22,23,24,25,26,28,29,30,31,32,35,36,37,38	**10,23,24,25,29,31,37,38**	
5	6,7,9,10,22,23,24,25,26,29,31,33,38	7,8,9,10,13,28,29,30,35,36	**7,9,10,29**	
6	7,8,9,10,11,12,13,14,15,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,35,38	5,12	**12**	
7	5,9,10,17,18,20,22,23,24,29,31,32,33,35	5,6,8,9,11,12,19,21,25,28	**5,9,**	
8	5,7,9,10,12,18,20,21,22,23,24,25,28,29,31,32,33,35,37	6,25	**25**	
9	5,7,10,12,13,17,18,20,21,22,23,24,27,29,31,32,33	5,6,7,8,10,12,13,15,17,18,19,21,23,24,25,28,30,33,37	**5,7,10,12,13,17,18,21,23,24,33**	
10	5,9,13,14,17,18,20,21,22,23,24,25,26,27,29,31,32,35,38	5,6,7,8,9,11,12,15,17,18,19,24,25,28,33,37	**5,9,17,18,24,25,**	
11	7,10,14,16,17,20,21,23,24,25,26,27,28,29,31,32,35,38	6,12,15,27,28,36	**27,28**	
12	6,7,9,10,11,14,16,17,18,20,21,22,23,24,25,26,27,28,29,31,32,33,35	6,8,9,15,17,18,23,24,25,27,28,33	**6,9,17,18,23,24,25,27,28,33**	
13	5,9,17,18,20,22,23,24,25,29,31,32,33,35,38	6,9,10,15,18,19,21,24,25,27,28,33,37	**9,18,24,25,33**	
14	29,31,32,33,38	6,10,11,12,15,16,18,19,20,21,22,23,24,25,26,27,28,30,33,35,36	**33**	
15	9,10,11,12,13,14,17,18,19,20,22,24,25,29,31,32,33,35,38	6,18,19,20,21,33	**18,19,20,33**	
16	14,32,33	11,12,18,19,20,23,24,30,33,35,36	**33**	
17	9,10,12,23,24,31	6,7,9,10,11,12,13,15,18,19,20,21,22,23,24,25,26,27,28,33,36,37	**9,10,12,23,24,**	
18	9,10,12,13,14,15,16,17,19,20,21,22,23,24,25,26,27,28,29,31,32,33	6,7,8,9,10,12,13,15,24,25	**9,10,12,13,15,24,25**	
19	7,9,10,13,14,15,16,17,20,21,22,23,26,28,29,31,32,35,36	6,7,8,9,10,12,13,15,24,25	**7,9,10,13,15,**	
20	14,15,16,17,23,29,31,32,35	15,18,21,22,23,24,25,30,36	**15,23,**	
21	7,9,13,14,15,17,19,20,22,23,26,28,29,32,38	6,7,8,9,10,11,12,13,15,18,19,21,22,23,24,25,26,27,28,35,36,37,38	**7,9,13,15,19,22,23,26,28,38**	
22	14,17,19,20,21,23,26,28,29	6,8,9,10,11,12,18,19,22,23,24,25	**19,23,**	
23	9,12,14,16,17,19,20,21,26,29,31,32,35,38	5,6,7,8,9,10,12,13,15,18,19,21,24,25,26,33	**9,12,19,21,26,**	
24	9,10,12,13,14,16,17,18,19,20,21,22,23,26,27,29,31,32,35,38	5,6,7,8,9,10,11,12,13,15,17,18,25,27,28,30,31,32,33,35,37	**9,1012,13,17,18,27,31,32,35**	
25	7,8,9,10,12,13,14,17,18,19,20,21,22,23,24,26,27,29,38	5,6,8,10,11,12,13,15,18,28,32,33	**8,10,12,13,18,**	
26	14,17,20,22,23,29,31,32,38	5,6,10,11,12,18,19,21,22,23,24,25,27	**22,23**	
27	11,12,13,14,17,19,20,23,24,26	6,9,10,11,12,18,24,25	**11,12,24**	
28	5,7,9,10,11,12,13,14,17,20,23,24,25,29,30,31,32,35,38	6,8,11,12,18,19,21,22,35	**11,12,35**	
29	5,31,32,38	5,6,7,8,9,10,11,12,13,14,15,18,19,20,21,22,23,24,25,26,28,30,35,36	**5**	
30	5,9,14,16,19,23,24,29,31,32,33,36	28,35,38		
31	24,33	5,6,7,8,9,10,11,12,13,14,15,17,18,19,20,23,24,26,28,29,30,32,33,35,36,38	**24,33**	
32	24,25,31,33,36	5,6,7,8,9,10,11,12,13,14,15,16,18,19,20,21,23,24,26,28,29,30,35,36,38	**24,36**	
33	9,10,12,13,14,15,16,17,22,23,24,25,31	5,6,7,8,9,12,13,14,15,16,18,30,31,32,35,36	**9,12,13,14,15,16,31**	
34	5,7,9,10,17,24,29,30,31,32,35,37,38	5,6,8,12,23,24,30,38	**5,24,30,38**	
35	5,14,16,20,24,28,29,30,31,32,33,38	6,7,8,10,11,12,13,15,19,20,23,24,28	**20,24,28,**	
36	5,11,14,16,17,19,20,29,31,32,33	19,30,32,38	**19,32**	

Table (6.6) Level of Variables – Level II

Level II was developed once the top-level poor performance factors were listed in the previous Level I, they were removed/ deleted from consideration. i.e. Factor 1 (Lack of effective Project Management. Inadequate experience of project team from all parties), Factor 2 (Insufficient team building during design and EPC0 and Factor 3 (Inappropriate overall organization structure linking all project teams) were removed from the table. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,9,10,11,12,13,14,16,18,20,22,23,24,25,27,28,29,30,31,35,37,38	5,6,7,8,10,12,15,19,24,28,30,33,36,37	**6,10,12,24,28,30,37**	
2	7,12,13,18,25,30,31,37,38	5,6,28,33,36,37	**37**	
3	7,12,13,17,23,24,25,29,31,33,37,38	5,6,15,28,30,36,37	**37**	
4	10,23,24,25,29,31,33,37,38	5,6,7,8,9,10,11,13,14,15,17,18,20,21,22,23,24,25,26,28,29,30,31,35,36,37,38	**10,23,24,25,29,31,37,38**	
5	6,7,9,10,22,23,24,25,26,29,31,33,38	7,8,9,10,13,28,29,30,35,36	**7,9,10,29**	
6	7,8,9,10,11,12,13,14,15,17,18,20,21,22,23,24,25,26,27,28,29,31,33,35,38	5,12	**12**	
7	5,9,10,17,18,20,22,23,24,29,31,33,35	5,6,8,9,11,12,21,25,28	**5,9,**	
8	5,7,9,10,12,18,20,21,22,23,24,25,28,29,31,33,35,37	6,25	**25**	
9	5,7,10,12,13,17,18,20,21,22,23,24,27,29,31,33	5,6,7,8,10,12,13,15,17,18,21,23,24,25,28,30,33,37	**5,7,10,12,13,17,18,21,23,24,33**	
10	5,9,13,14,17,18,20,21,22,23,24,25,26,27,29,31,35,38	5,6,7,8,9,11,12,15,17,18,24,25,28,33,37	**5,9,17,18,24,25,**	
11	7,10,14,16,17,20,21,23,24,25,26,27,28,29,31,35,38	6,12,15,27,28,36	**27,28**	
12	6,7,9,10,11,14,16,17,18,20,21,22,23,24,25,26,27,28,29,31,33,35	6,8,9,15,17,18,23,24,25,27,28,33	**6,9,17,18,23,24,25,27,28,33**	
13	5,9,17,18,20,22,23,24,25,29,31,33,35,38	6,9,10,15,18,21,24,25,27,28,33,37	**9,18,24,25,33**	
14	29,31,33,38	6,10,11,12,15,16,18,20,21,22,23,24,25,26,27,28,30,33,35,36	**33**	
15	9,10,11,12,13,14,17,18,20,22,24,25,29,31,33,35,38	6,18,20,21,33	**18,20,33**	
16	14,33	11,12,18,20,23,24,30,33,35,36	**33**	
17	9,10,12,23,24,31	6,7,9,10,11,12,13,15,18,20,21,22,23,24,25,26,27,28,33,36,37	**9,10,12,23,24,**	
18	9,10,12,13,14,15,16,17,20,21,22,23,24,25,26,27,28,29,31,33	6,7,8,9,10,12,13,15,24,25	**9,10,12,13,15,24,25**	
19	7,9,10,13,14,15,16,17,20,21,22,23,26,28,29,31,35,36	6,7,8,9,10,12,13,15,24,25	**7,9,10,13,15,**	
20	14,15,16,17,23,29,31,35	15,18,21,22,23,24,25,30,36	**15,23,**	
21	7,9,13,14,15,17,20,22,23,26,28,29,38	6,7,8,9,10,11,12,13,15,18,21,22,23,24,25,26,27,28,35,36,37,38	**7,9,13,15,22,23,26,28,38**	
22	14,17,20,21,23,26,28,29	6,8,9,10,11,12,18,22,23,24,25	**23**	
23	9,12,14,16,17,20,21,26,29,31,35,38	5,6,7,8,9,10,12,13,15,18,21,24,25,26,33	**9,12,21,26,**	
24	9,10,12,13,14,16,17,18,20,21,22,23,26,27,29,31,35,38	5,6,7,8,9,10,11,12,13,15,17,18,25,27,28,30,31,33,35,37	**9,10,12,13,17,18,27,31,35**	
25	7,8,9,10,12,13,14,17,18,20,21,22,23,24,26,27,29,38	5,6,8,10,11,12,13,15,18,28,33	**8,10,12,13,18,**	
26	14,17,20,22,23,29,31,38	5,6,10,11,12,18,21,22,23,24,25,27	**22,23**	
27	11,12,13,14,17,20,23,24,26	6,9,10,11,12,18,24,25	**11,12,24**	
28	5,7,9,10,11,12,13,14,17,20,23,24,25,29,30,31,35,38	6,8,11,12,18,21,22,35	**11,12,35**	
29	5,31,38	5,6,7,8,9,10,11,12,13,14,15,18,20,21,22,23,24,25,26,28,30,35,36	**5**	
30	5,9,14,16,23,24,29,31,33,36	28,35,38		
31	24,33	5,6,7,8,9,10,11,12,13,14,15,17,18,20,23,24,26,28,29,30,33,35,36,38	**24,33**	
32	24,25,31,33,36	5,6,7,8,9,10,11,12,13,14,15,16,18,20,21,23,24,26,28,29,30,35,36,38	**24,36**	
33	9,10,12,13,14,15,16,17,22,23,24,25,31	5,6,7,8,9,12,13,14,15,16,18,30,31,35,36	**9,12,13,14,15,16,31**	
34	5,7,9,10,17,24,29,30,31,35,37,38	5,6,8,12,23,24,30,38	**5,24,30,38**	
35	5,14,16,20,24,28,29,30,31,33,38	6,7,8,10,11,12,13,15,20,23,24,28	**20,24,28,**	

Table (6.7) Level of Variables – Level III

Level III was developed once the top-level poor performance factors were listed in the previous Level II, they were removed/ deleted from consideration. i.e. Factor 19 (Mega size, Design complexity and complications) and Factor 32 (Financial issues of Contractor during execution) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,9,10,11,12,13,14,16,18,22,23,25,27,29,30,31,35,37,38	5,6,7,8,10,12,15,19,30,33,36,37	**6,10,12,30,37**	
2	7,12,13,18,25,30,31,37,38	5,6,33,36,37	**37**	
3	7,12,13,17,23,25,29,31,33,37,38	5,6,15,30,36,37	**37**	
4	10,23,25,29,31,33,37,38	5,6,7,8,9,10,11,13,14,15,17,18,21,22,23,25,26,29,30,31,35,36,37,38	**10,23,25,29,31,37,38**	
5	6,7,9,10,22,23,25,26,29,31,33,38	7,8,9,10,13,29,30,35,36	**7,9,10,29**	
6	7,8,9,10,11,12,13,14,15,17,18,21,22,23,25,26,27,29,31,33,35,38	5,12	**12**	
7	5,9,10,17,18,22,23,29,31,33,35	5,6,8,9,11,12,21,25,28	**5,9,**	
8	5,7,9,10,12,18,21,22,23,25,29,31,33,35,37	6,25	**25**	
9	5,7,10,12,13,17,18,21,22,23,27,29,31,33	5,6,7,8,10,12,13,15,17,18,21,23,25,30,33,37	**5,7,10,12,13,17,18,21,23,33**	
10	5,9,13,14,17,18,21,22,23,25,26,27,29,31,35,38	5,6,7,8,9,11,12,15,17,18,25,33,37	**5,9,17,18,25,**	
11	7,10,14,16,17,21,23,25,26,27,29,31,35,38	6,12,15,27,36	**27**	
12	6,7,9,10,11,14,16,17,18,21,22,23,25,26,27,29,31,33,35	6,8,9,15,17,18,23,25,27,33	**6,9,17,18,23,25,27,33**	
13	5,9,17,18,22,23,25,29,31,33,35,38	6,9,10,15,18,21,25,27,33,37	**9,18,25,33**	
14	29,31,33,38	6,10,11,12,15,16,18,21,22,23,25,26,27,30,33,35,36	**33**	
15	9,10,11,12,13,14,17,18,22,25,29,31,33,35,38	6,18,21,33	**18,33**	
16	14,33	11,12,18,23,30,33,35,36	**33**	
17	9,10,12,23,31	6,7,9,10,11,12,13,15,18,21,22,23,25,26,27,33,36,37	**9,10,12,23**	
18	9,10,12,13,14,15,16,17,21,22,23,25,26,27,29,31,33	6,7,8,9,10,12,13,15,25	**9,10,12,13,15,25**	
19	7,9,10,13,14,15,16,17,21,22,23,26,29,31,35,36	6,7,8,9,10,12,13,15,25	**7,9,10,13,15,**	
20	14,15,16,17,23,29,31,35	15,18,21,22,23,25,30,36	**15,23**	
21	7,9,13,14,15,17,22,23,26,29,38	6,7,8,9,10,11,12,13,15,18,21,22,23,25,26,27,35,36,37,38	**7,9,13,15,22,23,26,38**	
22	14,17,21,23,26,28,29	6,8,9,10,11,12,18,22,23,25	**23**	
23	9,12,14,16,17,21,26,29,31,35,38	5,6,7,8,9,10,12,13,15,18,21,25,26,33	**9,12,21,26,**	
24	9,10,12,13,14,16,17,18,21,22,23,26,27,29,31,35,38	5,6,7,8,9,10,11,12,13,15,17,18,25,27,30,31,33,35,37	**9,10,12,13,17,18,27,31,35**	
25	7,8,9,10,12,13,14,17,18,21,22,23,26,27,29,38	5,6,8,10,11,12,13,15,18,33	**8,10,12,13,18,**	
26	14,17,22,23,29,31,38	5,6,10,11,12,18,21,22,23,25,27	**22,23**	
27	11,12,13,14,17,23,26	6,9,10,11,12,18,25	**11,12**	
28	5,7,9,10,11,12,13,14,17,23,25,29,30,31,35,38	6,8,11,12,18,21,22,35	**11,12,35**	
29	5,31,38	5,6,7,8,9,10,11,12,13,14,15,18,21,22,23,25,26,30,35,36	**5**	
30	5,9,14,16,23,29,31,33,36	35,38		
31	33	5,6,7,8,9,10,11,12,13,14,15,17,18,23,26,29,30,33,35,36,38	**33**	
32	25,31,33,36	5,6,7,8,9,10,11,12,13,14,15,16,18,20,21,23,26,29,30,35,36,38	**36**	
33	9,10,12,13,14,15,16,17,22,23,25,31	5,6,7,8,9,12,13,14,15,16,18,30,31,35,36	**9,12,13,14,15,16,31**	
34	5,7,9,10,17,24,29,30,31,35,37,38	5,6,8,12,23,30,38	**5,30,38**	

Table (6.8) Level of Variables – Level IV

Level IV was developed once the top-level poor performance factors were listed in the previous Level III, they were removed/ deleted from consideration. i.e. Factor 20 (Design Variations or changes in client requirement), Factor 24 (Delayed or insufficient design information from owner) and Factor 28 (Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,9,10,11,12,13,14,16,18,22,23,25,27,29,31,35,37	6,7,8,10,12,15,19,33,36,37	**6,10,12,37**	
2	7,12,13,18,25,31,37	6,33,36,37	**37**	
3	7,12,13,17,23,25,29,31,33,37	6,15,36,37	**37**	
4	10,23,25,29,31,33,37	6,7,8,9,10,11,13,14,15,17,18,21,22,23,25,26,29,31,35,36,37	**10,23,25,29,31,37**	
5	6,7,9,10,22,23,25,26,29,31,33	7,8,9,10,13,29,35,36	**7,9,10,29**	
6	7,8,9,10,11,12,13,14,15,17,18,21,22,23,25,26,27,29,31,33,35	12	**12**	
7	9,10,17,18,22,23,29,31,33,35	6,8,9,11,12,21,25,28	**9**	
8	7,9,10,12,18,21,22,23,25,29,31,33,35,37	6,25	**25**	
9	7,10,12,13,17,18,21,22,23,27,29,31,33	6,7,8,10,12,13,15,17,18,21,23,25,33,37	**7,10,12,13,17,18,21,23,33**	
10	9,13,14,17,18,21,22,23,25,26,27,29,31,35	6,7,8,9,11,12,15,17,18,25,33,37	**9,17,18,25,**	
11	7,10,14,16,17,21,23,25,26,27,29,31,35	6,12,15,27,36	**27**	
12	6,7,9,10,11,14,16,17,18,21,22,23,25,26,27,29,31,33,35	6,8,9,15,17,18,23,25,27,33	**6,9,17,18,23,25,27,33**	
13	9,17,18,22,23,25,29,31,33,35	6,9,10,15,18,21,25,27,33,37	**9,18,25,33**	
14	29,31,33	6,10,11,12,15,16,18,21,22,23,25,26,27,33,35,36	**33**	
15	9,10,11,12,13,14,17,18,22,25,29,31,33,35	6,18,21,33	**18,33**	
16	14,33	11,12,18,23,33,35,36	**33**	
17	9,10,12,23,31	6,7,9,10,11,12,13,15,18,21,22,23,25,26,27,33,36,37	**9,10,12,23**	
18	9,10,12,13,14,15,16,17,21,22,23,25,26,27,29,31,33	6,7,8,9,10,12,13,15,25	**9,10,12,13,15,25**	
19	7,9,10,13,14,15,16,17,21,22,23,26,29,31,35,36	6,7,8,9,10,12,13,15,25	**7,9,10,13,15,**	
20	14,15,16,17,23,29,31,35	15,18,21,22,23,25,36	**15,23**	
21	7,9,13,14,15,17,22,23,26,29	6,7,8,9,10,11,12,13,15,18,21,22,23,25,26,27,35,36,37	**7,9,13,15,22,23,26**	
22	14,17,21,23,26,28,29	6,8,9,10,11,12,18,22,23,25	**23**	
23	9,12,14,16,17,21,26,29,31,35,38	6,7,8,9,10,12,13,15,18,21,25,26,33	**9,12,21,26,**	
24	9,10,12,13,14,16,17,18,21,22,23,26,27,29,31,35	6,7,8,9,10,11,12,13,15,17,18,25,27,31,33,35,37	**9,10,12,13,17,18,27,31,35**	
25	7,8,9,10,12,13,14,17,18,21,22,23,26,27,29	6,8,10,11,12,13,15,18,33	**8,10,12,13,18,**	
26	14,17,22,23,29,31	6,10,11,12,18,21,22,23,25,27	**22,23**	
27	11,12,13,14,17,23,26	6,9,10,11,12,18,25	**11,12**	
28	9,10,11,12,13,14,17,23,25,29,31,35	6,8,11,12,18,21,22,35	**11,12,35**	
29	31	6,7,8,9,10,11,12,13,14,15,18,21,22,23,25,26,35,36		
30	14,16,23,29,31,33,36	35		
31	33	6,7,8,9,10,11,12,13,14,15,17,18,23,26,29,33,35,36,	**33**	
32	25,31,33,36	6,7,8,9,10,11,12,13,14,15,16,18,20,21,23,26,29,35,36	**36**	
33	9,10,12,13,14,15,16,17,22,23,25,31	6,7,8,9,12,13,14,15,16,18,31,35,36	**9,12,13,14,15,16,31**	

Table (6.9) Level of Variables – Level V

Level V was developed once the top-level poor performance factors were listed in the previous Level IV, they were removed/ deleted from consideration. i.e. Factor 5 (Project Manager does not have full authority), Factor 30 (Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors) and Factor 38 (Poor technical decision by PMC during tendering) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,10,11,18,22,23,25,27,29,35,37	6,7,8,10,19,33,36,37	**6,10,37**	
2	7,18,25,37	6,33,36,37	**37**	
3	7,17,23,25,29,33,37	6,36,37	**37**	
4	10,23,25,29,33,37	6,7,8,10,11,17,18,21,22,23,25,26,29,35,36,37	**10,23,25,29,37**	
5	6,7,10,22,23,25,26,29,33	7,8,10,13,29,35,36	**7,10,29**	
6	7,8,10,11,17,18,21,22,23,25,26,27,29,33,35			
7	10,17,18,22,23,29,33,35	6,8,11,21,25,28		
8	7,10,18,21,22,23,25,29,33,35,37	6,25	**25**	
9	7,10,17,18,21,22,23,27,29,33	6,7,8,10,17,18,21,23,25,33,37	**7,10,17,18,21,23,33**	
10	17,18,21,22,23,25,26,27,29,35	6,7,8,11,17,18,25,33,37	**17,18,25,**	
11	7,10,17,21,23,25,26,27,29,35	6,27,36	**27**	
12	6,7,10,11,17,18,21,22,23,25,26,27,29,33,35	6,8,17,18,23,25,27,33	**6,17,18,23,25,27,33**	
13	17,18,22,23,25,29,33,35	6,10,18,21,25,27,33,37	**18,25,33**	
14	29,33	6,10,11,18,21,22,23,25,26,27,33,35,36	**33**	
15	10,11,17,18,22,25,29,33,35	6,18,21,33	**18,33**	
16	33	11,18,23,33,35,36	**33**	
17	10,23	6,7,10,11,18,21,22,23,25,26,27,33,36,37	**10,23**	
18	10,17,21,22,23,25,26,27,29,33	6,7,8,10,25	**10,25**	
19	7,10,17,21,22,23,26,29,35,36	6,7,8,10,25	**7,10**	
20	17,23,29,35	18,21,22,23,25,36	**23**	
21	7,17,22,23,26,29	6,7,8,10,11,18,21,22,23,25,26,27,35,36,37	**7,22,23,26**	
22	17,21,23,26,28,29	6,8,10,11,18,22,23,25	**23**	
23	17,21,26,29,35,38	6,7,8,10,18,21,25,26,33	**21,26,**	
24	10,17,18,21,22,23,26,27,29,35	6,7,8,10,11,17,18,25,27,33,35,37	**10,17,18,27,35**	
25	7,8,10,17,18,21,22,23,26,27,29	6,8,10,11,18,33	**8,10,18,**	
26	17,22,23,29	6,10,11,18,21,22,23,25,27	**22,23**	
27	11,17,23,26	6,10,11,18,25	**11**	
28	10,11,17,23,25,29,35	6,8,11,18,21,22,35	**11,35**	
29		6,7,8,10,11,18,21,22,23,25,26,35,36		
30	23,29,33,36	35		
31	33	6,7,8,10,11,17,18,23,26,29,33,35,36,	**33**	
32	25,33,36	6,7,8,10,11,18,20,21,23,26,29,35,36	**36**	

Table (6.10) Level of Variables – Level VI

Level VI was developed once the top-level poor performance factors were listed in the previous Level V, they were removed/ deleted from consideration. i.e. Factor 9 (Issues regarding permissions / approvals from other stakeholders), Factor 12 (Lack of mechanism for recording, analyzing, and transferring project lessons learned), Factor 13 (Inadequate control procedures from owner side to monitor the progress and delay), Factor 14 (Incomplete or inaccurate cost estimate by owner & EPC Contractors), Factor 15 (Inadequate or improper planning/schedule from Owner to deliver the project), Factor 16 (Poor estimation of labor productivity by EPC and Factor 31 (Delay in procurement by Contractor) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,10,11,18,22,23,25,27,29,35,37	6,7,8,10,19,33,37	**6,10,37**	
2	7,18,25,37	6,33,37	**37**	
3	7,17,23,25,29,33,37	6,37	**37**	
4	10,23,25,29,33,37	6,7,8,10,11,17,18,21,22,23,25,26,29,35,37	**10,23,25,29,37**	
5	6,7,10,22,23,25,26,29,33	7,8,10,13,29,35	**7,10,29**	
6	7,8,10,11,17,18,21,22,23,25,26,27,29,33,35			
7	10,17,18,22,23,29,33,35	6,8,11,21,25,28		
8	7,10,18,21,22,23,25,29,33,35,37	6,25	**25**	
9	7,10,17,18,21,22,23,27,29,33	6,7,8,10,17,18,21,23,25,33,37	**7,10,17,18,21,23,33**	
10	17,18,21,22,23,25,26,27,29,35	6,7,8,11,17,18,25,33,37	**17,18,25,**	
11	7,10,17,21,23,25,26,27,29,35	6,27	**27**	
12	6,7,10,11,17,18,21,22,23,25,26,27,29,33,35	6,8,17,18,23,25,27,33	**6,17,18,23,25,27,33**	
13	17,18,22,23,25,29,33,35	6,10,18,21,25,27,33,37	**18,25,33**	
14	29,33	6,10,11,18,21,22,23,25,26,27,33,35	**33**	
15	10,11,17,18,22,25,29,33,35	6,18,21,33	**18,33**	
16	33	11,18,23,33,35	**33**	
17	10,23	6,7,10,11,18,21,22,23,25,26,27,33,37	**10,23**	
18	10,17,21,22,23,25,26,27,29,33	6,7,8,10,25	**10,25**	
19	7,10,17,21,22,23,26,29,35	6,7,8,10,25	**7,10**	
20	17,23,29,35	18,21,22,23,25	**23**	
21	7,17,22,23,26,29	6,7,8,10,11,18,21,22,23,25,26,27,35,37	**7,22,23,26**	
22	17,21,23,26,28,29	6,8,10,11,18,22,23,25	**23**	
23	17,21,26,29,35,38	6,7,8,10,18,21,25,26,33	**21,26,**	
24	10,17,18,21,22,23,26,27,29,35	6,7,8,10,11,17,18,25,27,33,35,37	**10,17,18,27,35**	
25	7,8,10,17,18,21,22,23,26,27,29	6,8,10,11,18,33	**8,10,18,**	
26	17,22,23,29	6,10,11,18,21,22,23,25,27	**22,23**	
27	11,17,23,26	6,10,11,18,25	**11**	
28	10,11,17,23,25,29,35	6,8,11,18,21,22,35	**11,35**	
29		6,7,8,10,11,18,21,22,23,25,26,35		
30	23,29,33	35		
31	33	6,7,8,10,11,17,18,23,26,29,33,35,	**33**	

Table (6.11) Level of Variables – Level VII

Level VII was developed once the top-level poor performance factors were listed in the previous Level VI, they were removed/ deleted from consideration. i.e. Factor 36 (Limited capability of local contractor) was removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,10,11,18,22,23,25,27,29,35,37	6,7,8,10,19,37	**6,10,37**	
2	7,18,25,37	6,37	**37**	
3	7,17,23,25,29,37	6,37	**37**	
4	10,23,25,29,37	6,7,8,10,11,17,18,21,22,23,25,26,29,35,37	**10,23,25,29,37**	
5	6,7,10,22,23,25,26,29	7,8,10,13,29,35	**7,10,29**	
6	7,8,10,11,17,18,21,22,23,25,26,27,29,35			
7	10,17,18,22,23,29,35	6,8,11,21,25,28		
8	7,10,18,21,22,23,25,29,35,37	6,25	**25**	
9	7,10,17,18,21,22,23,27,29	6,7,8,10,17,18,21,23,25,37	**7,10,17,18,21,23**	
10	17,18,21,22,23,25,26,27,29,35	6,7,8,11,17,18,25,37	**17,18,25,**	
11	7,10,17,21,23,25,26,27,29,35	6,27	**27**	
12	6,7,10,11,17,18,21,22,23,25,26,27,29,35	6,8,17,18,23,25,27	**6,17,18,23,25,27**	
13	17,18,22,23,25,29,35	6,10,18,21,25,27,37	**18,25**	
14	29	6,10,11,18,21,22,23,25,26,27,35		
15	10,11,17,18,22,25,29,35	6,18,21	**18**	
16		11,18,23,35		
17	10,23	6,7,10,11,18,21,22,23,25,26,27,37	**10,23**	
18	10,17,21,22,23,25,26,27,29	6,7,8,10,25	**10,25**	
19	7,10,17,21,22,23,26,29,35	6,7,8,10,25	**7,10**	
20	17,23,29,35	18,21,22,23,25	**23**	
21	7,17,22,23,26,29	6,7,8,10,11,18,21,22,23,25,26,27,35,37	**7,22,23,26**	
22	17,21,23,26,28,29	6,8,10,11,18,22,23,25	**23**	
23	17,21,26,29,35,38	6,7,8,10,18,21,25,26	**21,26,**	
24	10,17,18,21,22,23,26,27,29,35	6,7,8,10,11,17,18,25,27,35,37	**10,17,18,27,35**	
25	7,8,10,17,18,21,22,23,26,27,29	6,8,10,11,18	**8,10,18,**	
26	17,22,23,29	6,10,11,18,21,22,23,25,27	**22,23**	
27	11,17,23,26	6,10,11,18,25	**11**	
28	10,11,17,23,25,29,35	6,8,11,18,21,22,35	**11,35**	
29		6,7,8,10,11,18,21,22,23,25,26,35		
30	23,29	35		

Table (6.12) Level of Variables – Level VIII

Level VIII was developed once the top-level poor performance factors were listed in the previous Level VII, they were removed/ deleted from consideration. i.e. Factor 33 (Delay in mobilization during Design & EPC) was removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,10,18,22,23,25,27,29,37	6,7,8,10,19,37	**6,10,37**	
2	7,18,25,37	6,37	**37**	
3	7,17,23,25,29,37	6,37	**37**	
4	10,23,25,29,37	6,7,8,10,17,18,21,22,23,25,26,29,37	**10,23,25,29,37**	
5	6,7,10,22,23,25,26,29	7,8,10,13,29	**7,10,29**	
6	7,8,10,17,18,21,22,23,25,26,27,29			
7	10,17,18,22,23,29	6,8,21,25,28		
8	7,10,18,21,22,23,25,29,35,37	6,25	**25**	
9	7,10,17,18,21,22,23,27,29	6,7,8,10,17,18,21,23,25,37	**7,10,17,18,21,23**	
10	17,18,21,22,23,25,26,27,29	6,7,8,17,18,25,37	**17,18,25,**	
11	7,10,17,21,23,25,26,27,29	6,27	**27**	
12	6,7,10,17,18,21,22,23,25,26,27,29	6,8,17,18,23,25,27	**6,17,18,23,25,27**	
13	17,18,22,23,25,29	6,10,18,21,25,27,37	**18,25**	
14	29	6,10,18,21,22,23,25,26,27		
15	10,17,18,22,25,29	6,18,21	**18**	
16		18,23		
17	10,23	6,7,10,18,21,22,23,25,26,27,37	**10,23**	
18	10,17,21,22,23,25,26,27,29	6,7,8,10,25	**10,25**	
19	7,10,17,21,22,23,26,29	6,7,8,10,25	**7,10**	
20	17,23,29	18,21,22,23,25	**23**	
21	7,17,22,23,26,29	6,7,8,10,18,21,22,23,25,26,27,37	**7,22,23,26**	
22	17,21,23,26,28,29	6,8,10,18,22,23,25	**23**	
23	17,21,26,29,38	6,7,8,10,18,21,25,26	**21,26,**	
24	10,17,18,21,22,23,26,27,29	6,7,8,10,17,18,25,27,37	**10,17,18,27**	
25	7,8,10,17,18,21,22,23,26,27,29	6,8,10,18	**8,10,18,**	
26	17,22,23,29	6,10,18,21,22,23,25,27	**22,23**	
27	17,23,26	6,10,18,25		

Table (6.13) Level of Variables – Level IX

Level IX was developed once the top-level poor performance factors were listed in the previous Level VIII, they were removed/ deleted from consideration. i.e. Factor 11 (Lack of IT use in communication and information Management) and Factor 35 (Less time for EPC Tendering & too many bidders) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,10,18,25,27,29,37	6,7,8,10,19,37	**6,10,37**	
2	7,18,25,37	6,37	**37**	
3	7,17,25,29,37	6,37	**37**	
4	10,25,29,37	6,7,8,10,17,18,21,25,26,29,37	**10,25,29,37**	
5	6,7,10,25,26,29	7,8,10,13,29	**7,10,29**	
6	7,8,10,17,18,21,25,26,27,29			
7	10,17,18,29	6,8,21,25,28		
8	7,10,18,21,25,29,35,37	6,25	**25**	
9	7,10,17,18,21,27,29	6,7,8,10,17,18,21,25,37	**7,10,17,18,21**	
10	17,18,21,25,26,27,29	6,7,8,17,18,25,37	**17,18,25,**	
11	7,10,17,21,25,26,27,29	6,27	**27**	
12	6,7,10,17,18,21,25,26,27,29	6,8,17,18,25,27	**6,17,18,25,27**	
13	17,18,25,29	6,10,18,21,25,27,37	**18,25**	
14	29	6,10,18,21,25,26,27		
15	10,17,18,25,29	6,18,21	**18**	
16		18		
17	10	6,7,10,18,21,25,26,27,37	**10**	
18	10,17,21,25,26,27,29	6,7,8,10,25	**10,25**	
19	7,10,17,21,26,29	6,7,8,10,25	**7,10**	
20	17,29	18,21,25		
21	7,17,26,29	6,7,8,10,18,21,25,26,27,37	**7,26**	
22	17,21,26,28,29	6,8,10,18,25		
23	17,21,26,29,38	6,7,8,10,18,21,25,26	**21,26,**	
24	10,17,18,21,26,27,29	6,7,8,10,17,18,25,27,37	**10,17,18,27**	
25	7,8,10,17,18,21,26,27,29	6,8,10,18	**8,10,18,**	

Table (6.14) Level of Variables – Level X

Level X was developed once the top-level poor performance factors were listed in the previous Level IX, they were removed/ deleted from consideration. i.e. Factor 22 (Lack of Engineering clear roles/goals) and Factor 23 (Poor quality of deliverables by FEED Designer) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,25,27,29,37	6,7,19,37	**6,37**	
2	7,25,37	6,37	**37**	
3	7,17,25,29,37	6,37	**37**	
4	25,29,37	6,7,17,21,25,26,29,37	**25,29,37**	
5	6,7,25,26,29	7,13,29	**7,29**	
6	7,17,21,25,26,27,29			
7	17,29	6,21,25,28		
8	7,21,25,29,35,37	6,25	**25**	
9	7,17,21,27,29	6,7,17,21,25,37	**7,17,21**	
10	17,21,25,26,27,29	6,7,17,25,37	**17,25,**	
11	7,17,21,25,26,27,29	6,27	**27**	
12	6,7,17,21,25,26,27,29	6,17,25,27	**6,17,25,27**	
13	17,25,29	6,21,25,27,37	**25**	
14	29	6,21,25,26,27		
15	17,25,29	6,21		
16		18		
17		6,7,21,25,26,27,37		
18	17,21,25,26,27,29	6,7,25	**25**	
19	7,17,21,26,29	6,7,25	**7**	
20	17,29	21,25		
21	7,17,26,29	6,7,21,25,26,27,37	**7,26**	
22	17,21,26,28,29	6,25		
23	17,21,26,29,38	6,7,21,25,26	**21,26,**	
24	17,21,26,27,29	6,7,17,25,27,37	**17,27**	

Table (6.15) Level of Variables – Level XI

Level XI was developed once the top-level poor performance factors were listed in the previous Level X, they were removed/ deleted from consideration. i.e. Factor 8 (Excessive Bureaucracy in Owner's organization), Factor 10 (Slow decision making & Lack of staff involvement from Owner side) and Factor 18 (Lack of Client Participation in Major Milestones during Design) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,25,29,37	6,7,19,37	**6,37**	
2	7,25,37	6,37	**37**	
3	7,25,29,37	6,37	**37**	
4	25,29,37	6,7,21,25,26,29,37	**25,29,37**	
5	6,7,25,26,29	7,13,29	**7,29**	
6	7,21,25,26,29			
7	29	6,21,25,28		
8	7,21,25,29,35,37	6,25	**25**	
9	7,21,29	6,7,21,25,37	**7,21**	
10	21,25,26,29	6,7,25,37	**25**	
11	7,21,25,26,29	6		
12	6,7,21,25,26,29	6,25	**6,25**	
13	25,29	6,21,25,37	**25**	
14	29	6,21,25,26		
15	25,29	6,21		
16		18		
17		6,7,21,25,26,37		
18	21,25,26,29	6,7,25	**25**	
19	7,21,26,29	6,7,25	**7**	
20	29	21,25		
21	7,26,29	6,21,25,26,37	**7,26**	
22	21,26,28,29	6,25		
23	21,26,29,38	6,7,21,25,26	**21,26,**	

Table (6.16) Level of Variables – Level XII

Level XII was developed once the top-level poor performance factors were listed in the previous Level XI, they were removed/ deleted from consideration. i.e. Factor 17 (Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor) and Factor 27 (Outdated design Software) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,25,29,37	6,7,19,37	**6,37**	
2	7,25,37	6,37	**37**	
3	7,25,29,37	6,37	**37**	
4	25,29,37	6,7,25,29,37	**25,29,37**	
5	6,7,25,29	7,13,29	**7,29**	
6	7,25,29			
7	29	6,25,28		
8	7,25,29,35,37	6,25	**25**	
9	7,29	6,7,25,37	**7**	
10	25,29	6,7,25,37	**25**	
11	7,25,29	6		
12	6,7,25,29	6,25	**6,25**	
13	25,29	6,25,37	**25**	
14	29	6,25		
15	25,29	6		
16		18		
17		6,7,25,37		
18	25,29	6,7,25	**25**	
19	7,29	6,7,25	**7**	
20	29	25		
21	7,29	6,25,37	**7**	
22	28,29	6,25		

Table (6.17) Level of Variables – Level XIII

Level XIII was developed once the top-level poor performance factors were listed in the previous Level XII, they were removed/ deleted from consideration. i.e. Factor 21 (Inadequate project Objective and scope definition by Owner and FEED designer) and Factor 26 (Inconsistency between specification, prevailing international standards and owner's procedures / Specifications) were removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,25,29,37	6,19,37	**6,37**	
2	25,37	6,37	**37**	
3	25,29,37	6,37	**37**	
4	25,29,37	6,25,29,37	**25,29,37**	
5	6,25,29	13,29	**29**	
6	25,29			
7	29	6,25,28		
8	25,29,35,37	6,25	**25**	
9	29	6,25,37		
10	25,29	6,25,37	**25**	
11	25,29	6		
12	6,25,29	6,25	**6,25**	
13	25,29	6,25,37	**25**	
14	29	6,25		
15	25,29	6		
16		18		
17		6,25,37		
18	25,29	6,25	**25**	
19	29	6,25		
20	29	25		

Table (6.18) Level of Variables – Level XIV

Level XIV was developed once the top-level poor performance factors were listed in the previous Level XIII, they were removed/ deleted from consideration. i.e. Factor 7 (Frequent Owner Interference) was removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	6,29,37	6,19,37	**6,37**	
2	37	6,37	**37**	
3	29,37	6,37	**37**	
4	29,37	6,29,37	**29,37**	
5	6,29	13,29	**29**	
6	29			
7	29	6,28		
8	29,35,37	6		
9	29	6,37		
10	29	6,37		
11	29	6		
12	6,29	6	**6**	
13	29	6,37		
14	29	6		
15	29	6		
16		18		
17		6,37		

Table (6.19) Level of Variables – Level XV

Level XV was developed once the top-level poor performance factors were listed in the previous Level XIV, they were removed/ deleted from consideration. i.e. Factor 25 (Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance)) was removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	29,37	19,37	**37**	
2	37	37	**37**	
3	29,37	37	**37**	
4	29,37	29,37	**29,37**	
5	29	13,29	**29**	
6	29			
7	29	28		
8	29,35,37			
9	29	37		
10	29	37		
11	29			

Table (6.20) Level of Variables – Level XVI

Level XVI was developed once the top-level poor performance factors were listed in the previous Level XV, they were removed/ deleted from consideration. i.e. Factor 6 (Insufficient & inexperienced management personnel from Owner) was removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1	37	19,37	**37**	
2	37	37	**37**	
3	37	37	**37**	
4	37	37	**37**	

Table (6.21) Level of Variables – Level XVII

Level XVII was developed once the top-level poor performance factors were listed in the previous Level XVI, they were removed/ deleted from consideration. i.e. Factor 29 (Delay in Tendering and award schedule) was removed. Then, the same process was repeated to find out the factors in the next level.

Variables	Reachability Sets	Antecend Set	Intersection Set	Level
1		19		
2				
3				

Table (6.22) Level of Variables – Level XVIII

Level XVIII was developed once the top-level poor performance factors were listed in the previous Level XVII, they were removed/ deleted from consideration. i.e. Factor 37 - Delay in Tendering and award schedule) was removed and identified remaining factor. i.e. Factor 19 (Mega size, Design complexity and complications).

6.4 Step 4: Conical Matrix

A conical matrix is produced by clustering poor performance factors in the same level across the rows and columns of the final reachability matrix. The drive power of a factor is derived by summing up the number of ones in the rows and its dependence power by summing up the number of ones in the columns (Hasan M.A., Shankar R. and Sarkis J., 2007; Raj T., Attri R. and Jain V., 2012; Attri R., Grover S., Dev N. and Kumar D., 2012). Next, drive power and dependence power ranks are calculated by giving highest ranks to the factors that have the maximum number of ones in the rows and columns, respectively.

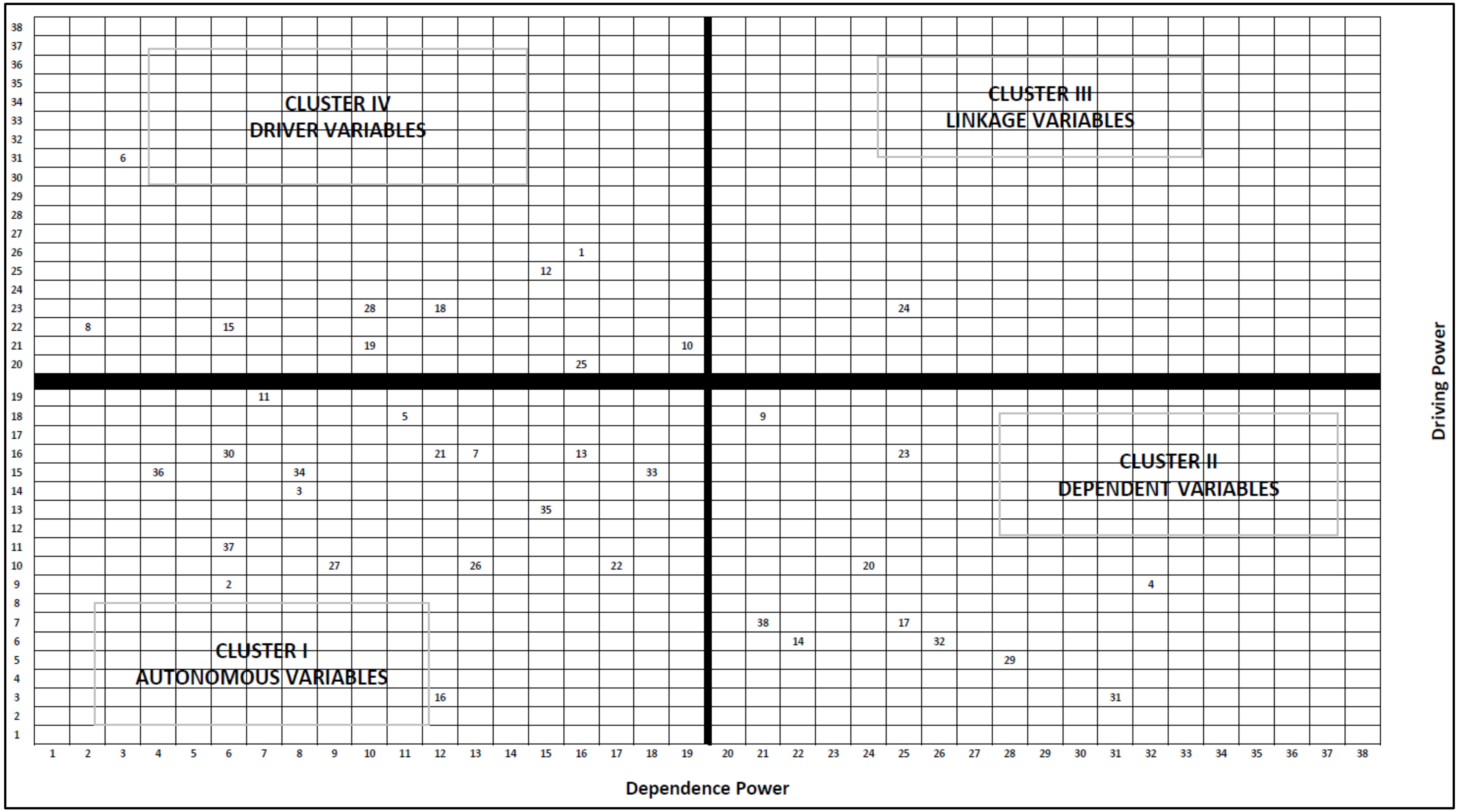


Figure (6.4) CLUSTERS OF VARIABLES

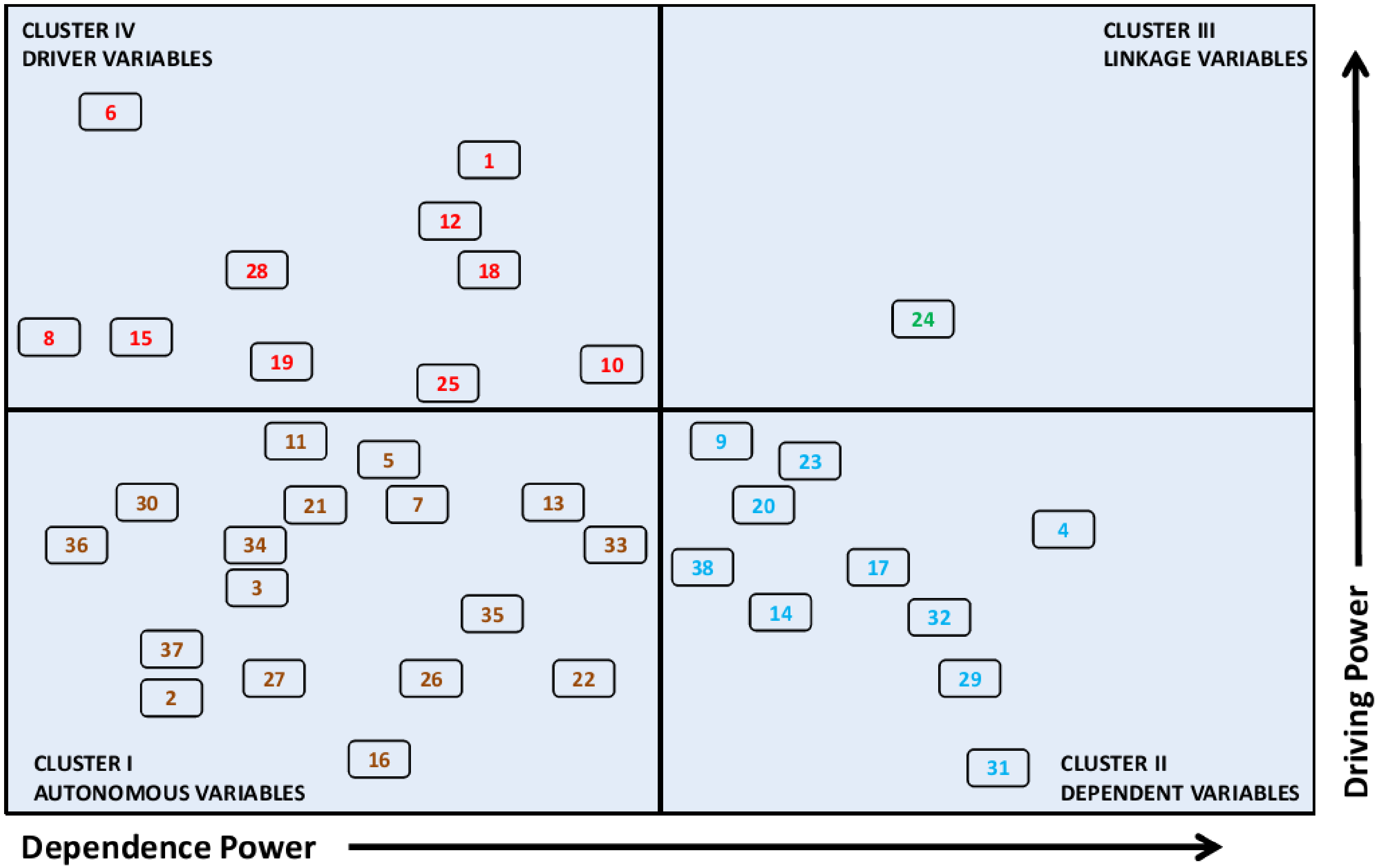


Figure (6.5) CLUSTERS OF VARIABLES WITH ARROW

In the cluster, the Autonomous factors have weak driving power and weak dependence power too. This means they are relatively disconnected from the system, i.e. they have few links, which may be very strong, and these factors are , factors no 16 - Poor estimation of labor productivity by EPC; 2 - Insufficient team building during design and EPC; 27 - Outdated design Software; 26 - Inconsistency between specification, prevailing international standards and owner's procedures / Specifications; 22 - Lack of Engineering clear roles/goals; 37 - Limited authority of PMC Consultant; 35 - Less time for EPC tendering & too many bidders; 3 - Inappropriate overall organization structure linking all project teams; 36 - Limited capability of Contractor; 34 - Flexibility of Client to adopt technical changes; 33 - Delay in mobilization during Design & EPC; 30 - Inadequate contractor experience - All Phases, unfamiliar with Regulations, Policies & Local law changes or issues and Lack of knowledge in social &cultural factors; 21 - Inadequate project Objective and scope definition by Owner and FEED designer; 7 - Frequent Owner Interference; 13 - Inadequate control procedures from owner side to monitor the progress and delay; 5 - Project Manager does not have full authority; 11 - Lack of IT use in communication and information Management. Linkage factors have strong driving power as well as strong dependence power. i.e. these factors are unbalanced in the fact that any action on these factors will have an effect on others and also a feedback effect on themselves, these factors are factors number 24 - Delayed or insufficient design information from owner. The dependent factors have weak driving power however, they have strong dependence power, and these factors are 31 - Delay in procurement by Contractor; 29 - Delay in Tendering and award schedule; 14 - Incomplete or inaccurate cost estimate by owner & EPC Contractors.; 32 - Financial issues of Contractor during execution; 38 - Poor Technical decision during tendering by PMC; 17 - Delay in preparation and approval of documents by Owner and FEED Consultant / Contractor; 4 - Conflicts / Disputes between Owner stakeholders (Project team and Operations); 20 - Design Variations or changes in client requirement; 23 - Poor quality of deliverables by FEED Designer; 9 - Issues regarding permissions/ approvals from other stakeholders.

The Driver Variables factors have strong driving power but weak dependence power. i.e. a factor with a very strong driving power, called the ‘key/maser factor’ falls into the category of independent or linkage factors, these are, factor no 25 - Lack of Communication between FEED engineers and other Stakeholders (Operation & Maintenance); 19 - Mega size, Design complexity and complications; 10 - Slow decision making & Lack of staff involvement from Owner side; 8 - Excessive Bureaucracy in Owner's organization.; 15 - Inadequate or improper Planning from Owner to deliver the project; 28 - Wrong choice of contract type or Improper bidding and award Strategy by Owner and Inappropriate bidding instruction during bidding; 18 - Lack of Client Participation in Major Milestones during Design; 12 - Lack of mechanism for recording, analyzing, and transferring project lessons learned; 1 - Lack of effective Project Management, Inadequate experience of project team from all parties; 6 - Insufficient & inexperienced management personnel from Owner.

6.5 Step 5: Diagraph

From the conical form of reachability matrix, the preliminary digraph including transitive links is developed. It is generated by nodes and lines of edges, (Hasan M.A., Shankar R. and Sarkis J., 2007; Raj T., Attri R. and Jain V., 2012; Attri R., Grover S., Dev N. and Kumar D., 2012). After removing the indirect links, a final digraph is developed. This digraph is used to show the poor performance factors and their interdependencies in terms of nodes and edges (i.e. the digraph is the visual representation of the poor performance factors and their interdependence) (Attri R., Grover S., Dev N. and Kumar D., 2012; Raj T. and Attri R., 2010). The will lead to the top level factor being positioned at the top of the digraph and the second level factor being placed at the second position and so on, until the bottom level is placed at the lowest position in the digraph (Attri R., Grover S., Dev N. and Kumar D., 2012; Raj T. and Attri R., 2010). Step 6: Final ISM Model: The digraph is replaced into an ISM model by replacing nodes of the factors with factors names and statements (Ravi V. and Shankar R., 2005; Singh M.D., Shankar R., Narain R. and Agarwal A., 2003; Raj T. and Attri R., 2011).

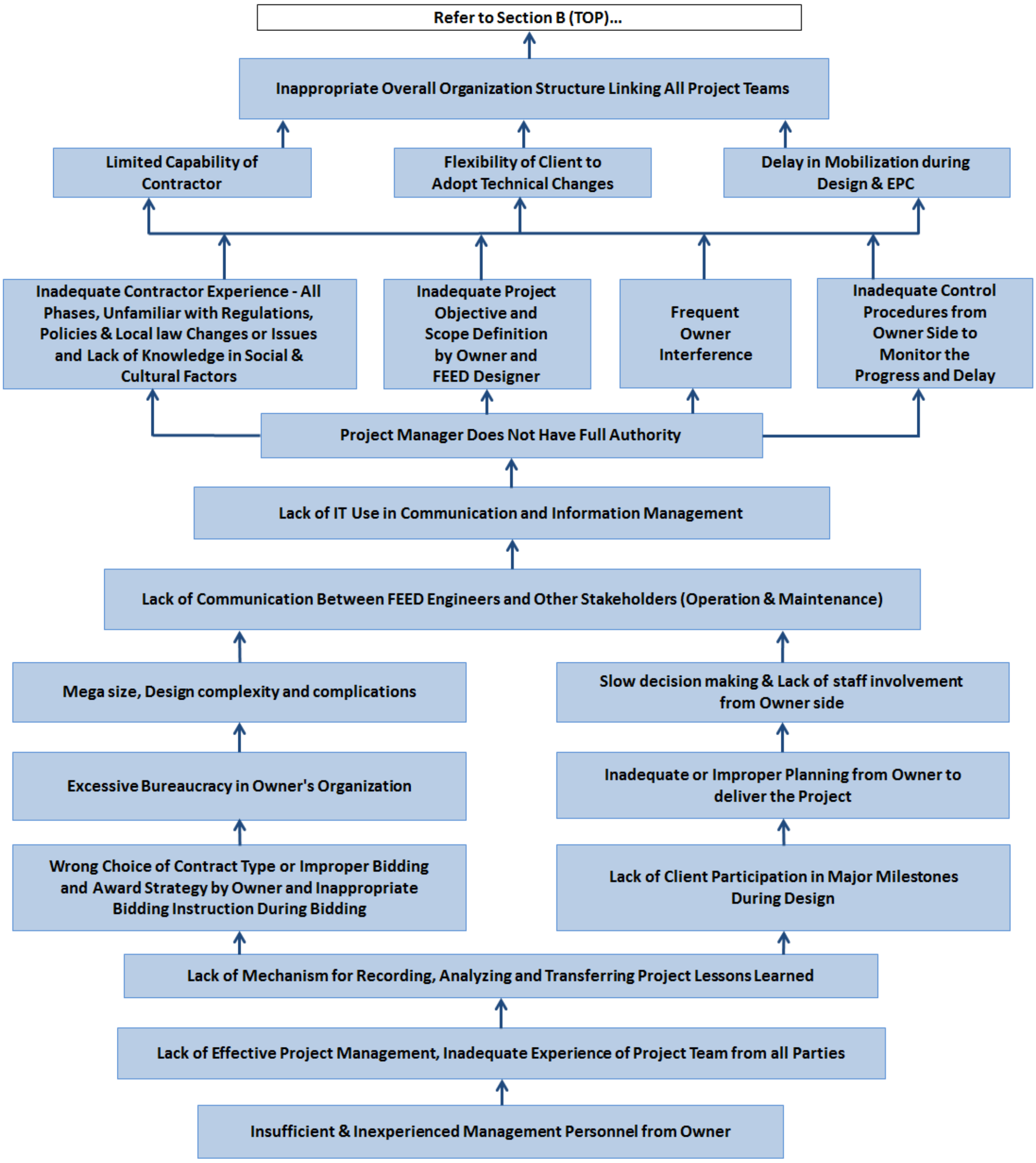


Figure (6.6) Section – A (Bottom) – ISM BASED MODEL

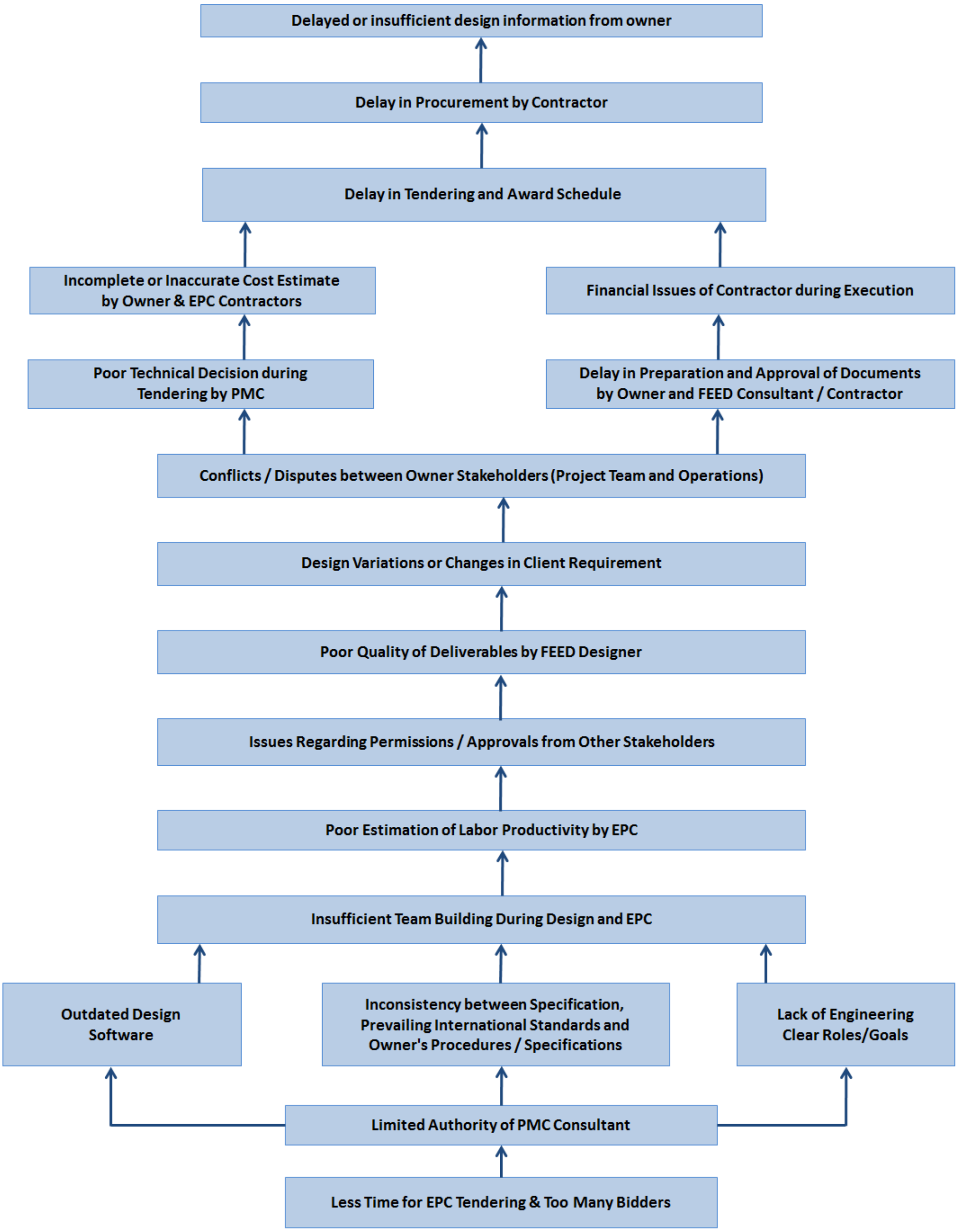


Figure (6.6) Section – B (Top) – ISM BASED MODEL

Figure (6.6) ISM Based Model

Digraph is converted into an ISM model by substituting nodes of the factors with related poor performance factors. The digraph is developed, where the top level factors are placed and positioned at the top of the digraph and second level factors are positioned at second position, third level factors are positioned at the third positions and so on, once we reach the last position (bottom level) the factors is placed at the lowest position in the digraph.

6.6 Advantages of ISM Approach

ISM presents various advantages such as (1) the process is methodical; the computer is programmed to consider all possible pair wise relations of system elements. (2) The process is also very efficient; i.e. depending on the context, the use of transitive inference could minimise the number of the required relational queries by from 50-80%. (3) No deep knowledge of the fundamental process is required of the interviewees; they simply must possess enough understanding of the poor performance factors in order to be able to reply to the series of relational queries generated by the system. (4) It guides and records the results of group deliberations on complex and large number of factors in an efficient and systematic manner. (5) It produces a structured model or graphical representation of the original problem situation that can be communicated more effectively to others.

6.7 Limitations of ISM approach

if there are many variables to a problem such as 28 poor performance factors, i.e. an increase in the number of variables to a problem could increase the complexity of the ISM methodology. So the researcher could only consider limited number of poor performance factors in the development of ISM model. Other factors which are least important or least impacting the poor performance could be deleted in the development of ISM model.

6.8 Applications of ISM Approach

ISM can be applied at a high level of concept such as is needed for long range planning of poor performance factors or variables. It can also be utilised at a more solid level to process and structure details related to a problem or activity such as process design, framework, project planning, engineering problems (Dev N., Samsher, Kachhwaha S.S. and Attri R., 2012; Chidambaranathan S., Muralidharan C. and Deshmukh S.G., 2009; Li W.L., Humphreys P., Chan L.Y. and Kumaraswamy M., 2003).

6.9 ISM Conclusion

ISM provides a well-ordered, directional framework for complex problems, and gives O&G stakeholders a realistic and clear image of poor performance and which factors are involved and influential. The process involved the identification of factors, the definition of their interrelationships, and rank ordering and direction to illuminate complex problems from a systems perspective. The process transforms unclear, poorly articulated examples of poor performance into visible and well- defined factors. The interrelations between these factors helped to identify the key factors related to poor performance. After identification of the key factors behind poor performance from the literature and confirmation from the case study, it will be easy to develop the required strategy to handle each factor and identify the best solution, with minimum impact. ISM provides a means of integrating the various insights of participating groups, and is capable of handling the large number of factors and their relationships typical of poor performance projects. It is experiential in measuring the adequacy of model formulation, and leads to insights about system conduct.

The ISM output has identified the interrelationships between factors, and their influence on project performance. It has located the factors in the cluster, where factors falling within the ‘autonomous’ cluster have weak driving power and weak dependence power. This means these factors are relatively disconnected, i.e. they have few links with other factors, which could be very strong. Factors within the ‘linkage’ cluster have strong driving power and strong dependence power, i.e.

these factors are unbalanced, and any action on these factors will affect others and also have a feedback effect on themselves. The factors which fall within the 'dependent' cluster have weak driving power but strong dependence power. The factors within the 'driver' cluster have strong driving power but weak dependence power. A factor with a very strong driving power, called the 'key/master factor' falls into the category of independent or linkage factors. By using the cluster distribution, and understanding each factor's position and relation with others from ISM, stakeholders can identify and focus on those factors with driving force and a key role, to try to resolve them early in the design phase and reduce their impact on other factors. The framework has identified these factors and their occurrence phase, where stakeholders, and the client project team in particular, should address and resolve them early to reduce their later influence. Factors with driving power are lack of communication between FEED engineers and other stakeholders (Operation & Maintenance), design complexity and complications, slow decision making & lack of staff involvement from owner side and inadequate or improper planning from owner to deliver the project. ISM has helped the researcher to identify the factors' relations and their cluster location, and therefore enabled the framework to identify and resolve these early to reduce their influence on performance.

From the digraph (Fig 6.5), the key factors behind poor performance were recorded. Poor project management from the owner often drives poor performance and project problems in the industry. Insufficient or inexperienced management staff from the owner, design consultant and construction contractor play a key role in poor performance. The linkage factors of lack of effective project management, and inadequate experience of project team members from all parties are second in terms of poor performance. These factors emphasise the role played by the project management team in project success, and their major contribution to poor performance. A lack of mechanism for recording, analysing and transferring project lessons learned is also a critical and important factor behind project performance, as is lack of client participation in major milestones during the design. Wrong choice of contract type also contributes. Delay in procurement by contractor or in the tendering and award schedule are less critical than these other factors.

Chapter 7. FINAL CONCEPTUAL FRAMEWORK

An initial framework has been developed to address the method of integrating key stakeholders and how the IPD principles will be conceptual. One of the objectives of the initial framework is to overcome the current common problems of all project execution strategies under a Design-Bid-Build delivery method and other strategies, where late integration among key stakeholders occurs, such as contractors, major/minor manufacturers, sub-contractors, where their involvement begins after completing the FEED design. Bringing together all stakeholders, such as interested contractors and vendors, together to participate during the FEED design phase will mitigate project uncertainties and expand their scope of understanding and technical knowledge. Contractors and manufacturers will also have the opportunity to understand the design basis; this will enrich the design and technical scope of the work and reduce the number of assumptions made by design consultants, which will eventually be considered by contractors and manufacturers and other parties during subsequent phases. The involvement of all stakeholders as early as possible in the design phase will also allow stakeholders to verify any constraints and market challenges in terms of execution, construction, delivery at site, installation, testing, commissioning and operation and maintenance, which will contribute to better understanding of schedule, cost and risk management.

A FEED design consultant usually develops the engineering document with less or no communication with manufacturers and without updates regarding the market situation, i.e. technology changes, availability of materials, deliverability and schedule. This is due to time limitations during the design phase, or design consultant engineers relying on previous knowledge and experience and not being up to date with market changes. Manufacturers' involvement and input will be captured and included during the design phase to cater for any technical and commercial; also it will expand the client and design consultant understanding. This can be starched to provide more ecumenical and schedule driven by the manufacturers. Nevertheless, integrating the manufacturers during the design phase means that all manufacturers' clarifications, options and technical deviations can be answered prior to any commercial commitment. The above should positively contribute towards better commercial bidding and realistic scheduling, since contractors along with manufacturers will be more likely to have the same technical understanding before the construction contract bidding. In the design phase, issues arise such as transportation, work permits, labour laws, lands releases, power connections, etc.. Similar issues appear in the later operation and maintenance stages. If the end-users are involved during the design, all of the operation and maintenance lessons learnt and concerns could be captured in the design and all the drawings, philosophies, documents, etc. will be incorporated in the design; this will assist in commissioning the facilities, operating and maintaining them with less risk and improving the productivity of end-users. This will also help end-users to identify and exclude manufacturers with poor previous records.

The proposed initial framework was to ensure that all of the essential stakeholders are involved during the design phase and that each possible factor is tackled by integrating all of the concerned stakeholders at the required time and event during each phase, the mainly Concept and FEED design phase (early phases), before any contractual obligations that restrict possible mitigation measures are agreed. The same approach can be extended from the concept phase to bring the owner together with other required stakeholders. As examples, the concept consultant and owner will collaborate with the end-user at a very early stage such as the design concept phase, where the owner will ensure that the ultimate project objectives are clearly communicated, documented. The concept design consultant will ensure that these objectives are well captured and defined and that all of the requirements are well developed. In addition, the end-users (operating and maintenance stakeholder) will be involved and integrated with the project team at the concept stage to ensure that all of their concerns are captured.

The initial framework will look at each possible poor performance factor, which could be resolved within the identified timeframe and with the involvement of related stakeholders. Based on data sampling, the factors related to design, project management, planning and communication have been thoroughly analysed as most literatures have listed the factors under these four categories as the highest rated factors causing poor project performance. Although other poor performance factor categories may also be addressed and resolved using the same approach, the research has focused on the most schedule-, quality- and cost-influencing factors. Other unlisted factors and groups may depend on the nature and conditions of particular projects. The resolvable factors in terms of design, project management, communication, and planning have been drafted based on the literature with the same factors, then validated and examined under case studies.

The final framework was updated to reflect all the made changes during the case studies and discussions and plotted as final framework as below.

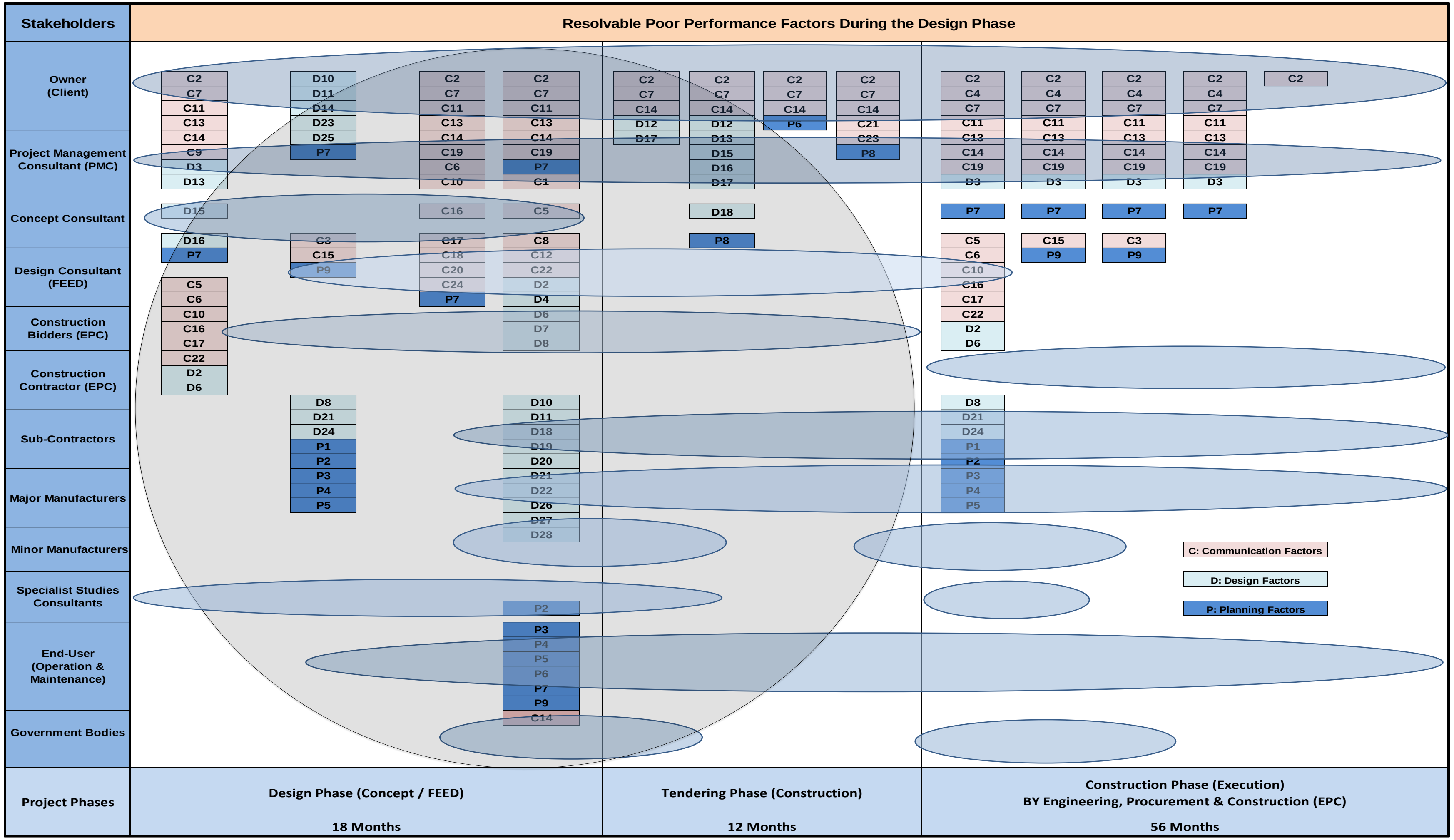


Figure (7.1) Final Conceptual Framework

The initial framework was plotted with a matrix structure where all key stakeholders are listed in the left-hand column, such as the owner, project management consultant (PMC), FEED designer, EPC contractor, major manufacturers/minor manufacturers, specialized study consultants, end users (operation and maintenance) and government bodies. On the bottom row, the project phases have been plotted based on the most common execution strategy (Design-bid- build), starting from early design phases (Concept and FEED), where several milestones need to be completed, such as, selecting and qualifying consultants for concept initialisation, before moving on to concept selection if more than one design proposal is presented. Once the design is complete, the owner moves to execute the bidding/tendering phase, where the owner invites all qualified contractors to bid for the scope; this duration varies from project to project based on the locations, complexity and other factors. One step later, once the bidding is completed, the execution phase begins by awarding the contract, then the first phase of execution is to start the detailed engineering, followed by procurement, then construction followed by commissioning and operating.

The matrix has plotted all of the factors related to design, project management, planning and communication as per their occurrence phase, which was validated by the case studies, i.e. factors which have occurred during the design will be plotted within the design phase; factors which occurred within the tendering or execution will be plotted under the execution and tendering phases; and repeated factors or those that occurred under more than one phase will also be plotted as per their occurrence frequency. The factor codes are detailed in the below table. The framework demonstrates each stakeholder’s participation and integration phase, i.e. the owner is required to participate during the entire project life cycle, as is the project management consultant (PMC). By this involvement, all of the covered factors should be addressed and tackled by both owner and PMC, and both should aim to resolve these factors. Resolving the repeated factors will result in addressing these factors early and avoid repeating them in the next phase of the project. The same is true of the other stakeholders, i.e. by involving them as early as possible in the design, this will allow them to resolve the factors related to their fields and concerns.

From the circle shape, it is expected that during the design phase (concept and FEED), the majority of the factors will be addressed and resolved, including the factors which occur at the construction and execution phase since those usually late-integrated stakeholders will be participating during the design stage of the framework and should bring forward their concerns at that stage. For example, once the government bodies are aware of the project during the design, all government guidelines and procedures will be captured and covered to ease the execution phase and eliminate any late changes in the design or in the ground. This construction contractor involvement will focus on the construction scope of the work and the interfacing section in the design phase; this will address all of the concerns and coordination and communication procedures.

The initial framework has been validated by the three case studies and several suggestions for improvement were captured from the case studies participants. The table below lists factors with their code in the framework, divided into four groups: communication, project management, design and planning. Management factors or groups were imbedded in the three groups above since they are mentioned under each, therefore they were not presented as a code in the framework or in the table below.

Discipline	Code	Finding	Phase when resolvable	Sub Phase
Communication	C1	Client Participation	FEED	Elaboration
	C2	Conflicts / Disputes	FEED,Tendering, EPC Execution	All Phases
	C3	Delay in approval during construction	EPC execution	Construction
	C4	Delayed design information	FEED, EPC Execution	Information Gathering, Detailed design
	C5	Excessive Bureaucracy in Owner's organization	FEED,Tendering, EPC Execution	All Phases
	C6	Improper Documentation of Project Objectives	FEED	Elaboration
	C7	Inadequate design team experience	FEED	FEED Consultant Selection
	C8	Insufficient Team Building	FEED, EPC Execution	All Phases
	C9	Issues regarding permissions/ approvals from other stakeholders	FEED	Elaboration
	C10	Lack of Communication between engineers / stakeholders	FEED, Tendering, EPC Execution	All Phases
	C11	Lack of IT use in communication and information management	FEED, EPC Execution	Information Gathering, Detailed design
	C12	Lack of mechanism for recording, analyzing, and transferring project lessons learned	FEED	Information Gathering
	C13	Owner Interference	FEED, EPC Execution	All Phases
	C14	Poor documentation	FEED, EPC Execution	Information Gathering, Detailed design
	C15	Slow decision making & Lack of staff involvement	FEED, EPC Execution	Elaboration, Detailed design
	C16	Social and cultural factor	Tendering	Contract Award
Design	D1	Change orders	FEED, EPC Execution	Elaboration, Detailed design
	D2	Delays in producing design documents	FEED, EPC Execution	Elaboration, Detailed design
	D3	Design complexity	FEED	Elaboraion
	D4	Design variations or changes in client requirement	Concept, FEED	Concept Selection, Elaboration
	D5	Engineering clear roles and goals	Tendering	CTC, TBA
	D6	Improper / Outdated design Software	FEED, Tendering	FEED Consultant Selection, TBA
	D7	Inadequate project scope definition	Tendering	CTC, TBA
	D8	Incomplete drawings/ specifications/documents	FEED, Tendering	Elaboration, TBA
	D9	Inconsistence of technical specifications	FEED	Elaboration
	D10	Insufficient design information	FEED, EPC Execution	Elaboration, Detailed design
	D11	Mega Size Projects	Concept	Concept selection
	D12	Mistakes and discrepancies in design	EPC execution	Detailed design
	D13	Unforeseen ground conditions or Insufficient Site data	FEED	Information Gathering
Planning	P1	Improper planning	FEED, EPC Execution	Elaboration, Detailed design
	P2	Inadequate or improper planning	FEED, EPC Execution	Elaboration, Detailed design
	P3	Incomplete or inaccurate cost estimate	FEED, Tendering	Elaboration, CBA
	P4	Lack of effective management	FEED, EPC Execution	All Phases
	P5	Poor Estimation of Labor productivity	Tendering	TBA, Contract Award

Figure (7.2) Factors Final List

The case studies have validated the framework and the participants came out with several improvements to be made. The first is to segregate the EPC awarded contractor from the EPC bidders and introduce a new stakeholder as EPC bidders in the left-hand column since those bidders will participate in the design stage while the EPC contractor is yet unknown and will come at later stage. The second suggestion was to include the government body within the stakeholders in the left-hand column as their role and participation in the design phase is critical for some projects. It was also suggested that the duration of each phase be pre-determined in certain ranges, i.e. bidding to be between 2 and 12 months, though obviously this can vary between projects. From the case study, the factors' occurrences were revised and more factors were repeated in various phases and this was reflected. The construction schedule represented the sequence of phases with their average duration. Duration varies according to project size from 33 to 60 months. The design varies from eight months to 15–20 months based on project location, complexity and various factors. The framework emphasises stakeholder integration and communication during the design stage.

An important point is the schedule, which could also be reduced as key stakeholders will enter the project very early and their knowledge and experience could be enriched very early in the design. This will allow their project team to understand the project, clarify the scope and issue their quotations for pricing to all manufacturers and sub-contractors early. This should contribute to reducing the bidding schedule and the length of time required for technical and commercial clarification. From the schedule, it can be seen that each phases will overlap to reflect this integration; this will also ensure that the owner invites interested bidders to participate in project bidding early in order to be involved in the design phase. On the other technical point view, Building Information Model (BIM) such as 30%, 60%, and 90% 3D design model could be developed with detailed information. In addition to the above, the tendering phase will be shortened since the same will be done during early design. The time float generally estimated for the execution phase could be lower, since design will now be executed using all procurement and constructability-related information from stakeholders, thereby the number of changes/variations in the design or changes in stakeholder expectations should be lower.

Chapter 8. CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

This research aimed to create a conceptual framework to implement IPD principles in Oil & Gas projects. This framework is required to involve stakeholders in Oil & Gas projects as early as possible during the design phase, to improve delivery of project objectives on time and within budget and improve project performance. This chapter will summarize the research strategy, conclusion and recommendations. It will also revisit the research questions, and set out the research output, the limitations and contributions of the work, and provide some ideas for its implementation.

8.2 Research Conclusions

1. The literature confirmed that the Oil & Gas industry suffers from poor performance of projects, and this has led to cost increases, budget overruns, and delays in schedules. The poor performance factors are global and typical in the industry. They are not specific to region or project size, with the same factors observed in various locations, and in projects of all sizes, although more typically in large-scale projects. Similar factors are seen in both the Oil & Gas industry and the general construction and infrastructure industries.

2. The current practices and execution strategies of Oil & Gas projects influence project delivery, and drive poor performance in the industry. Three widely-used practices and execution strategies were identified:

    1. Design-Bid-Build (D-B-B)

    2. Design-Build (D-B)

    3. Construction Manager at Risk.

    The Design-Bid-Build method was used for 57% of the O&G projects (by market share) over the last ten years, then Design-Build for 38%, and Construction at Risk for 5%.

3. There are other delivery strategies used by the O&G industry. These are mainly collaboration methods, particularly partnering and alliancing. Partnering is co-operation between the project owners and international investors or owners and execution contractors. They have common project objectives and goals to increase project efficiency and delivery by sharing experience and

resources and improving communication. Alliancing is another collaborative strategy and multi-part contracting approach and it allows a more collaborative environment and sharing of project risk between owners and others. Both partnering and alliancing require collaboration and integration between owner and contractor, but do not allow for full integration with other project stakeholders such as design consultants, manufacturers, and those responsible for operation and maintenance. Findings suggest that partnering had no effect on software integration, and was always secured by legal contracts, leaving no independent means to assure the quality and value of the design.

4. The majority of Oil & Gas and other infrastructure projects are executed and managed using a Stage-Gate Project Management Process. Such processes have limitations in managing complex, high-risk technologies and mega-projects, which was a major cause of project cancellation or significant delays in new product development projects. The Stage-Gate process was also found not to support early collaboration and integration between stakeholders. It is structured to complete each stage and phase separately, i.e. the design stage should be completed before moving to construction tendering, and award of tender before construction can start. This emphasized the need for a collaborative approach and clear integration as early as possible, and particularly from the design phase. The Stage-Gate process also caused early high or low cost and schedule estimates to be developed before sufficient design detailing had been completed. This effort and cancelling of some projects and delay in project progress while waiting for gate approvals is another limitation.

5. There are few databases or references about the Oil & Gas industry. The literature review was therefore expanded to include the broader construction and infrastructure sectors, including construction of factories, accommodation towers and compounds, hospitals, highways and airports. These extra references expanded the available information on execution strategies. A similar situation was found with literature on the factors affecting poor performance in O&G projects, and the review was expanded to cover construction and infrastructure. Again, this enriched understanding, and expanded the number of factors affecting performance to 1,065. Many of these factors were common to several projects, albeit described in slightly different terms.

6. The IPD, as a delivery method, is new to all the industries and there is no implementation in the Oil & Gas sector yet. This approach had been used in some of the larger infrastructure and governmental construction projects, but

was often not well-structured in terms of the liabilities between the client and stakeholders such as the design consultant and construction contractor. Its collaborative approach during the early phases could, however, often resolve factors linked to poor project performance. Stakeholder integration during the design phase would help all stakeholders to share their concerns and collaborate to deliver their requirements. There were, however, no clear structure or process maps to understand how the IPD approach could be used to involve Oil & Gas project stakeholders. The IPD approach requires a contractual procedure to integrate all stakeholders early during the design phase, but no clear contractual terms and conditions have been developed to secure this.

7. The factors behind poor performance of Oil & Gas projects were grouped into design, communication, project management, resources, contract, planning, environment, quality, regulation and procurement. Design, planning, project management and communication factors had the biggest influence on project performance, with project management being the most important. Out of 1,067 poor performance factors, 98 seem to have a major role in project performance. Poor performance factors related to design, planning, project management and communication groups are:

1	Lack of effective project management. Inadequate experience of project team from all parties.
2	Insufficient team building during design and EPC.
3	Inappropriate overall organisation structure linking all project teams.
4	Conflicts/disputes between stakeholders (owner, project team and operations).
5	Project manager does not have full authority.
6	Insufficient & inexperienced management personnel from owner
7	Frequent owner interference.
8	Excessive bureaucracy in owner's organisation.
9	Issues regarding permissions/approvals from other stakeholders.
10	Slow decision-making and lack of staff involvement from owner side.
11	Lack of IT use in communication and information management.
12	Lack of mechanism for recording, analysing, and transferring project lessons learned.
13	Inadequate control procedures from owner side to monitor the progress and delay.
14	Incomplete or inaccurate cost estimate by owner & EPC contractors.
15	Inadequate or improper planning/schedule from owner to deliver the project.
16	Poor estimation of labour productivity by EPC.
17	Delay in preparation and approval of documents by owner and FEED consultant/contractor.
18	Lack of client participation in major milestones during design.
19	Mega size, design complexity and complications.

20	Design variations or changes in client requirement.
21	Inadequate project objective and scope definition by owner and FEED designer.
22	Lack of engineering clear roles/goals.
23	Poor quality of deliverables by FEED designer.
24	Delayed or insufficient design information from owner.
25	Lack of communication between FEED engineers and other stakeholders (operation & maintenance).
26	Inconsistency between specification, prevailing international standards and owner's procedures/specifications.
27	Outdated design software.
28	Wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding.
29	Delay in tendering and award schedule.
30	Inadequate contractor experience - all phases, unfamiliar with regulations, policies & local law changes or issues and lack of knowledge in social & cultural factors.
31	Delay in procurement by contractor.
32	Financial issues of contractor during execution.
33	Delay in mobilization during design & EPC.
34	Flexibility of client to adopt technical changes.
35	Less time for EPC tendering & too many bidders.
36	Limited capability of local contractor.
37	Limited authority of PMC consultant.
38	Poor technical decision by PMC during tendering.

8. The most influential group was project management, where weak and poor management skills was key. Late client involvement was also a key factor behind poor performance. Incomplete design and outdated specifications were the most important factors under design. Unrealistic schedule, poor planning and underestimating labour productivity were key under planning. Unclear communication matrix, and late involvement of key stakeholders were the most important under communication.

9. The design phase is the most influential phase in the project lifecycle. Time and effort spent during this phase by stakeholders can greatly improve project performance. Many of the factors occurring during the construction phase have their root in the design phase. More work during the design phase could therefore prevent problems occurring during construction. Construction tendering and bidding was less influential than the design and construction phases, and there was a limited number of performance factors related to this phase.

10. The factors were then related to particular stakeholders to determine who was responsible for each factor. Owners and design consultants play the major role in the later construction phase. The owner is the most influential stakeholder in

the project, and factors can be resolved if owners pay more attention and take an active role. The factors were also grouped by time of occurrence to see if they were repeated in different phases and times or occurred in a single phase. The design phase was identified as the most important phase of the project, and tendering as the least influential. Factors occurring in the construction phase were generally rooted in the design phase and could be overcome if they were addressed during that phase. The research also examined whether factors were repeated within projects of the same scale and in the same location/region, or varied by location. The factors were found to be similar across regions, probably because of standard and international design guidelines.

11. The conceptual framework was designed to integrate all project stakeholders early in the design phase, to mitigate and resolve the main factors behind poor performance, and particularly those related to design, communication, planning and project management, the framework is also expected to resolve other factors related to resources, procurement, environment and other groups.

12. The conceptual framework was validated by using three case studies selected from the Oil & Gas industry. Two of these cases had suffered from poor performance, major delays and serious cost impact. The third case study was also from the Oil & Gas industry but had less delay and no major cost impact. These cases were studied using semi-structured interviews and piloted questions. The interviewees were carefully selected based on their roles and responsibilities. Once the interviews were complete, a separate and combined data analysis was used to assess and fine-tune the initial framework based on the findings. The case studies introduced additional stakeholders such as construction bidders and governmental bodies, and also identified three main project phases (design, tender and build). The case studies also optimized the factors and distributed them across phases.

13. Interpretive Structural Modelling (ISM) has identified and confirmed the relationship between the factors related to poor performance. ISM also confirmed that the relations will be affected by the developed framework, i.e. resolving factors related to project management, design, planning and communication factors during the design phase using the developed framework will resolve other factors related to other groups such as procurement, resources, environment, government related factors, since these factors have linkage and driving power. Poor estimation of labour productivity, insufficient team building during design, outdated design software and inconsistency between specification were all important autonomous factors

with weak driving power and weak dependence power. Delayed or insufficient design information from owner is a linkage factor, and has strong driving power and strong dependence power. This factor is therefore unbalanced, and any action from this factor will have an effect on others and a feedback effect on itself. Delay in procurement by contractor, delay in tendering and award schedule, incomplete or inaccurate cost estimates by owner and contractors and financial issues of contractor during execution are all dependent factors with weak driving power and strong dependence power. Lack of communication between FEED engineers and other stakeholders (Operation & Maintenance), large size/design complexity and complications, slow decision making and lack of staff involvement from owner's side, excessive bureaucracy in owner's organization, inadequate or improper planning from owner to deliver the project, wrong choice of contract type or improper bidding and award strategy by owner and inappropriate bidding instruction during bidding are driver factors with strong driving power and weak dependence power. Factors with very strong driving power, called the 'key/master factors', are all independent or linkage factors.

14. Involving the construction contractors, major manufacturers and subcontractors during the design phase should resolve some of the factors which occur during the construction phase and will help the design consultant to improve the 3D modeling and provide better quantities and estimates. It should also increase competition among the construction bidders by providing prices and improving the schedule. Their involvement should be limited to providing lessons learnt from previous experience, and reviewing and commenting on the design documents to understand the project requirements and challenges. They should not be able to impose or sell their own preferred design or ideas.

15. Clients may need to introduce an incentive scheme to encourage potential bidders to participate in the design phase, and to cover their expenses in doing so.

16. Implementing the framework and involving government authorities and bodies early in the design phase should accelerate governmental approvals and obtain their timely support.

17. The conceptual framework could be implemented by several ways, such as inviting all stakeholders to attend design workshops, nominating specific people or teams to provide full time participation and integration with the project team, or enabling stakeholders to review the design documents remotely. It will be necessary to develop a contractual template to implement

the IPD principles to facilitate its implementation since no existing contract is available. It will be also important to promote the use of IPD principles in the Oil & Gas industry, explaining how this could help project performance, as there is currently limited awareness and knowledge of this system.

8.3 Research Recommendation.

This research makes the following recommendations:

- The Oil & Gas industry and academic bodies should study and publish papers on poor performance of projects.

- Oil & Gas industry case studies, with both good and poor performance should be developed to serve the industry.

- Oil & Gas companies should implement the new conceptual framework, and particularly involve all stakeholders during the design phase, to improve project performance.

- Owners and design consultants should ensure that construction contractors and manufacturers are involved as early as in the design phase of the project. The precise model of this integration is flexible.

- The Oil & Gas industry should spend more time and effort on the design phase, ensuring that the design documentation is completed in full, to address all project uncertainties.

- Contractual terms and conditions should be clearly set out to demonstrate that construction contractors and manufacturers are encouraged to participate in the design phase.

- The owner should take responsibility for leading the integration and collaboration, and may need to provide training to improve this area.

- Owners should invite manufacturers and governmental bodies to get involved during the design phase.

- The owner and design consultant should draw up a clear responsibility matrix for the design phase. This should include construction contractors, major manufacturers and governmental bodies to ensure that their role is very clear and does not overlap with that of the design consultant.

- The owner should ensure that stakeholders spend more time on team building at the design phase, to understand each other and to ensure that the project objectives and aims can be realised.

- The owner should develop an incentive scheme and provide compensation to encourage construction contractors and manufacturers to participate in the design phase.

- Future academic research should study possible implementation strategies and develop contractual terms and conditions.

8.4 Research Questions

This section provides the answers to the research questions outlined at the start of the process.

1. What are the current practices and execution strategies used for project delivery and performance in the Oil & Gas industry?

There are three main delivery strategies which dominate the Oil & Gas sector. These are Design-Bid-Build, Construction Management at Risk, and Design-Build. In total, 57% of projects examined had applied a Design-Bid-Build strategy, 38% a Design-Bid strategy, and 5% a Construction Management at Risk delivery strategy. These approaches all have a clear communication and interface gap between stakeholders, particularly the design consultant and the construction contractor and manufacturers. Design consultants also often disengage from projects once the design phase is complete. This leads to a lack of understanding of the design justifications, and in turn to further challenges during the construction phase.

2. What are the factors behind poor performance to help focus efforts to improve project performance and work practices of the Oil & Gas industry?

The three execution strategies have contributed to various factors that eventually led to poor project performance. These factors were grouped into a series of categories, covering design, planning, project management, procurement, contractual, environmental and other. Four groups dominated, design, planning, project management and communication. Project management and design factors were a driving force behind other factors. Major factors were weak project management teams from the client side, delay in approving documents, incomplete designs, poor client participation, lack of communication between stakeholders, owner interference, design changes and insufficient design information.

3. How can the IPD principles be implemented in the Oil & Gas industry?

Understanding IPD and its limitations have enabled the building of a new conceptual framework. This framework suggests that all the project stakeholders should be involved during the design phase. This involvement will enable stakeholders such as construction contractors and manufacturers to review and comment on the design documentation and specifications, and allow them to understand the basis for the design. They will also be able to set out challenges and difficulties that they will face during project execution. Any problem areas can then be addressed and resolved by all concerned.

4. How can project performance in the Oil & Gas industry be improved by implementing a conceptualised framework using IPD principles?

The case studies showed that the conceptual framework will bring together all the stakeholders during the design phase and so eliminate any communication gaps. This will enable the design to be improved, because the design consultant will be able to improve the design by better understanding of the likely execution problems.

8.5 Contribution of this Research

The research contributes to three areas: academia, governments/authorities and the Oil & Gas sector.

This research contributes to the academic sector by setting out the practical advantages and disadvantages of each strategy used in the Oil & Gas sector. It also identifies the most commonly-used strategy (Design-Bid-Build), and has identified and grouped poor performance factors to enable focus on the most influential groups (design, communication, project management and planning). This should help future academic researchers to look at other groups and analyse how these factors and groups influence other sectors. Clearer definitions of IPD, and of the current problems facing the industry will help future researchers to move forward from this report, and find solutions to these problems. This study did not implement the new conceptual framework in the market, and future research may consider its implementation and improvement. The study found limited literature on the Oil & Gas industry, identifying a key gap for future research to address. IPD contractual terms and conditions are not yet well-developed, so this could also be the basis for future research to identify problem areas and develop a clear contractual basis.

This study will help the Oil & Gas sector to understand, realize and identify poor performance factors, the reasons behind their occurrence, and which stakeholders contribute to each factor. It has also confirmed that the current project management strategies create clear communication and integration gaps between the key stakeholders. The sector must therefore find solutions to close this gap. One solution would be to involve construction contractors and key manufacturers as early as possible during the design phase. The developed conceptual framework could help to resolve the integration and communication gap; other solutions could also be developed.

This research will help governments and authorities to set up guidelines and policies to improve stakeholder collaboration and integration during the design phase. The authorities could also help the industry to understand the advantages of design improvements and early involvement of project stakeholders. Governments should develop guidelines to implement the IPD for larger projects and provide incentives for contractors and design consultants to use this approach. Government policies could be updated to address the integration requirements and develop process maps to implement IPD in their projects. All sectors should focus on the most influential factors, particularly design, communication, project management and planning. These four groups could play a major role in improving project performance.

8.6 Limitations of this Research

This research does have some limitations. First, it was limited to midstream and downstream projects in the Oil & Gas industry, i.e. projects related to constructing major pipeline networks, oil and gas production fields, gathering systems, power generation plants, refineries, petrochemical plants, and storage facilities. Projects related to oil and gas exploration and appraisal, such as seismic, drilling and piloting work, were not considered in this research because of the limited number of stakeholders involved. These tasks also have little investment value compared to mid and downstream projects, and are often limited to specific contractors or executed by the client. The primary and secondary data, the literature survey and case studies, did not involve any subsurface or drilling projects. The case studies were selected from Oil & Gas sector downstream projects, which meet the requirements for this research in terms of participants' roles during execution, scale, size and schedule.

This research did not cover low value projects, as these are presumed to have fewer stakeholders. Their early design will also be less complex with minimal design duration, and the procurement and manufacturing will be small and limited to a few manufacturers. The size and number of construction contractors and subcontractors will be small compared to projects with higher costs. Low to medium-scale projects are often awarded to construction contractors who have experience in handling smaller designing and procurement scopes, which makes these projects more competitive. However, such contractors do not necessarily have experience handling large-scale projects. The research focused on high value projects where the design duration is between 12 to 15 months, followed by a 12-month bidding period, and then construction for 48 to 54 months. This size of project follows the stage-gate process, where approvals go through various stages and gates to ensure that each stage passes its minimum requirements. The number of stakeholders is large, including clients, design consultants, project management consultants, government bodies, construction contractors, sub-contractors, major manufacturers, minor manufacturers and third-party consultancies.

Factors behind poor performance and current practices were covered in the literature review, and referenced in the appropriate sections, but this study focused on major factors with a measurable impact on project performance, which have been presented in many papers and are frequently referred to in the literature. Only factors related to four groups were addressed in this research (project management, design, communication and planning factors); other factors related to resources, procurement, quality, contracts and environment were not considered in the framework. Factors related to specific regions or projects were not addressed or listed in the research, and factors related to environments or government categories were excluded. There are therefore many other factors which could also affect project performance, and which may not be addressed by the recommendations of this report, which may limit its impact.

One strength of this research is that its scope was not limited to projects executed in the UAE or Middle East because the factors were recorded in various projects, regions and locations. The research is therefore applicable to all Oil & Gas projects worldwide, which are often similar in design, execution and financing methods, even though environmental conditions vary between locations. Projects in this sector are designed using international standards and well-known design consultants, and financing is provided by well-known international companies supporting Oil & Gas projects around the globe. The scope of the research was limited to creating a conceptual framework to implement IPD principles. Framework implementation was not considered in this study, although the interviewees often discussed it, and some suggestions emerging from those discussions are included in the next section. Detailed implementation guidance will, however, require further research.

8.7 The Implementation Practicality of the new Framework

This section identifies processes and practicalities of implementing the framework developed in this study. These processes and approaches were gathered and based on the comments made by the interviewees during the case studies. Although it was beyond the scope of the research, implementation practicality is important to the new knowledge that has been developed in this research.

Early stakeholder participation can be modeled and presented in many practical ways, but depends on the project's scale, complexity, criticality, stakeholder size and the willingness of the owner to obtain a high quality design and to value competitive and fair commercial prices. Framework implementation could also vary from project to project based on various aspects such as the number of stakeholders and criticality of their involvement.

From the research point of view, the best process to implement the framework is to allow stakeholders, particularly construction bidders, sub-contractors and major manufacturers, to participate and get involved from the design phase and provide them with clear roles and responsibility to avoid misunderstanding their involvement objectives. Their involvement can be extended to cover two practical approaches:

1. Provide a full time member of the owner project team. i.e. each construction bidder to nominate one person to be part of the owner team during the design phase. For example, bidder A might provide a process specialist, Bidder B a mechanical specialist, and bidder C a civil or electrical specialist. The role of these specialists is to identify any gaps or shortfalls in the design documents, improve the quality of the design document and ensure the design is complete. Their role is not to approve or endorse the design document, because that is the job of the owner project team and project management consultant team.
2. The owner would allow particular stakeholders, such as construction bidders, major manufacturers and other stakeholders, to participate and attend various design workshops to allow them to become familiar with the project challenges and the scope, and to identify any lack of clarity in the design. These workshops are technical workshops and usually form part of the design deliverables and represent major design milestones, such as Design Review workshop, PFD (Process Flow Diagram) workshop, P&ID (Piping & Instrument Diagram) review workshop, Risk Management workshop, flow assurance workshop, HAZOP workshop, 3D modeling workshops (30%, 60% and 90%), and value engineering workshops. The stakeholders' involvement will provide them with deep knowledge about the project size, nature and challenges and will allow them to review the design documents, PFDs and P&ID. Their feedback and comments can be considered and any design gaps or incomplete documents can be highlighted and actioned by the owner and the design consultant.

During the case study interviews, the researcher received various feedback on the practicality of implementing the framework. Interviewees were very interested in sharing their ideas about best practice and propose a process to implement the framework. The majority of the interviewees asked about a feasible model to bring construction contractors and major manufacturers in during the design phase. They extended the question to whether the owner should invite FEED bidders to enter the concept phase as early as possible, and ask them to participate in document reviews and workshops during the concept study. The owner could also supply them with the FEED scope of work and deliverables list for review and feedback, to clarify the scope of the project and list any missing deliverables for the design phase, before inviting the construction contractor into the design phase. This approach could easily be managed and implemented during the conceptual design phase if the owner decided to start the integration of stakeholders from this early point.

The most critical aspect of the framework is integrating the EPC contractor, construction sub-contractor, manufacturers and end users during the FEED design phase, because this is where all the design basis documents and deliverables are developed and locked. These include the Process Flow Diagram (PFD), Piping & Instrument Diagrams (P&IDs), plot plans, cause & effect, philosophies, specifications, datasheets, mass balance sheets, and 3D models. The owner has various options on how to manage this and involve all these stakeholders.

Option 1 is inviting all the EPC bidders to participate full-time during the FEED phase along with the client and FEED consultant. However, the number of participants from each bidder could be very high, which might make this unfeasible. Further study would be needed to examine whether this is possible.

Option 2 is similar to the first of the two practical approaches above. Each contractor who has been invited to bid for EPC, along with major manufacturers and special studies consultants, could provide some full-time engineers to work on specific functions during the design phase, where the FEED consultant and owner will also be involved, to form a Project Management Team (PMT). For example, bidder A could provide a process engineer, bidder B a mechanical engineer, bidder C someone to cover control, and so on. The role of these participants would not be to put forward their company’s design but to provide comments to improve the deliverables and the clarity of the documents by minimising uncertainty. Manufacturers and vendors could also be invited to participate. Their role would again be to improve the clarity of the specifications and data sheets rather than making changes to serve their own interests. Vendor comments could also be validated and cross-checked with other vendors to ensure open standards.

Option 3 is where government authorities and other stakeholders could participate in various technical and awareness workshops on subjects like logistics and transportation, temporary facilities design, constructability and permitted requirements. This would ensure that all government concerns are captured and addressed as early as possible in the design, to ease and facilitate timely approval. Operations and maintenance contractors could be involved to ensure that plot plan layouts, accessibility to various systems, previous lessons learned and vendors' experiences and after-support are captured in the scope of supply. Their involvement will also enrich the operating and maintenance philosophies and manuals. This process should make obtaining their endorsement of the related deliverables very smooth, which should in turn ease pre-commissioning and commissioning activities.

Option 4 is to include the EPC construction bidders, major manufacturers, and special studies consultants in the document review matrix (RACI matrix). This would mean providing certain deliverables for their review, comments and information. This can be done remotely without inviting them to visit the designer's office, which will minimise the number of participants at the FEED consultant's office.

Option 5 for implementation practicality is to request the invited bidders to participate in key project design review milestones such as reviews of hydraulic/dynamic modeling, plot plan, safety, sites data collection, HAZOP, P&ID, materials selection, and 3D modeling. This will provide a venue to discuss various aspects of the project, including any problems related to execution and manufacturing.

Option 6 is to request that bidders such as EPC construction bidders, major manufacturers and special studies consultants form a team to participate fully with the FEED design consultant and owner's PMT in the design office, or nominate one EPC to represent all the bidders. Again, their role would be to review and improve the design quality and reduce uncertainty, rather than impose their own company's ideas and designs.

Option 7 is currently used by a few owners, who require EPC construction bidders to provide a clear FEED endorsement statement during the EPC bidding to qualify for the EPC commercial bid submission. This approach takes place within a very limited timeframe, and does not enable large technical teams to review, comment and endorse the FEED design during the bidding phase. This could, however, be more practical if it is brought forward during the FEED stage, when the design parameters (production profiles) could be provided for bidders to run their own simulations.

Gathering all of the EPC bidders, along with the FEED design consultant and owner's PMT may be slightly unrealistic because of the large number of people involved. This could lead to extensions being required for the FEED stage, as well as other disadvantages. All of the above approaches and options require the owners, FEED consultant and contractors to buy into and support the project, since these approaches may have cost implications for them all. EPC construction bidders' and manufacturers' participation during the design phase will have an additional cost to them, which may be shared with or compensated for by owners in some cases. This could benefit the project and may be reflected in its commercial value. It could also improve the schedule for the owners, and would therefore repay the additional costs.

8.8 Future Areas of Research

There are several areas that would repay future study. Researchers could build on this research on poor performance factors related to specific stakeholders at the design, management, planning and communication stages of projects, and extend it to cover and investigate other factors linked to poor performance, such as contracts, resources, and procurement. This will help to expand knowledge about the wide range of factors influencing poor performance.

Researchers may wish to apply the new conceptual framework in practice and examine its limitations. This practical implementation will allow others to adapt and enhance the framework and develop processes to implement it, and also make recommendations for its effective implementation. Further case studies could be considered to add further validation and to understand the future challenges of IPD implementation.

Finally, researchers may wish to develop contractual guidelines and procedures to enhance this framework and overcome stakeholders' commercial risks in applying the IPD. The conceptual framework currently has no contractual framework, and it would be helpful to develop clear terms and conditions for its implementation.

Bibliography

Leicht, R. M., Molenaar, K. R., Messner, J. I., Franz, B. W., and Esmaeili, B. (2015). Maximizing Success in Integrated Projects: An Owner's Guide. Version 0.9, May. Available at http://bim.psu.edu/delivery.

Sinem Korkmaz, Vernon Miller, and Weida Sun, 2012 " Assessing Key Dimensions to Effective Innovation Implementation in Inter-Organizational Teams: An IPD Case".

Hans Wamelink, Jelle Koolwijk, Alijd van Doorn, 2007 "Integrated project delivery: the designer as integrator".

Volker L, & Klein R. (2010), Architect participation in integrated project delivery: the future mainspring of architectural design firms?, in: Design Management and Technology.

Renier, B., & Volker, L. (2008) The Architect as a System Integrator? Paper presented at the 24th Annual ARCOM Conference, 1-3 September, Cardiff, UK.

Klein, R. (2009), Designer led Design-Build, A study of barriers and opportunities for architects on integrated procurement, MSc thesis, TU Delft.

Manley, K (2002) Partnering and Alliancing on Road Projects in Australia and Internationally Road and Transport Research.

Mistry, D and Davis, P R (2009) A client's perspective of critical success factors in project alliances. in: Dainty, A.R.J. (Ed) Procs 25th Annual ARCOM Conference, 7-9 September 2009, Nottingham, UK, Association of Researchers in Construction Management.

Matthews, O., Howell, G. A. (2005). An Integrated Project Delivery: An Example of Relational Contracting Lean Construction Journal.

Walker, D H T and Keniger, M (2002) Quality management in construction: An innovative advance using project alliancing in Australia TQM Magazine.

Benedict D. Ilozor and David J. Kelly, 2012, "Building Information Modeling and Integrated Project Delivery in the Commercial Construction Industry: A Conceptual Study.

Singleton, M.S. and Hamzeh, F. (2011)." Implementing Integrated Project Delivery on Department of Navy Construction Projects, Lean Construction Journal".

Smith, R.E., Mossman, A. and Emmitt, S. (2011). "Lean and Integrated Project Delivery Special Issue, Lean Construction Journal".

Succar, B. (2009). Building Information Modeling Framework: A Research and Delivery Foundation for Industry Stakeholders.

Teicholz, P. (2004,). Labor Productivity Declines in the Construction Industry: Causes and Remedies, AEC bytes Viewpoints.

Tylor, E.B. "Primitive Culture, Researches into the Development of Mythology, Philosophy, Religion, Art, and Custom, London".

John Murray (20110), “U.S. Department of Commerce, Bureau of Economic Analysis”.

Wong, P. and Cheung, S. (2004) “Trust in Construction Partnering: Views From Parties of the Partnering Dance. International Journal of Project Management”.

Barry Jones, (2014) “Integrated project delivery (IPD) for maximizing design and construction considerations regarding sustainability”.

3D/International, Inc. (2005). “CM at Risk” [WWW document]. URL http://www.3di.com/toolbox/cmatrisk.pdf (visited 2005, April 1)..

A.H. Memom, Contractor perspective on time overrun factors in Malaysian construction projects. Int. J. Sci. Environ. Technol. 3(3), 1184–1192 (2014).

ABADIE, Richard, and Peter RAYMOND. "Correcting the course of capital 16. projects, plan ahead to avoid time and cost overruns down the road." Única edición, Londres, Gran Londres, Reino Unido, Price waterhouse Coopers (2013).

Abdelalim, Ahmed Mohamed, Omar A. El Nawawy, and Mohamed S. Bassiony. "Quantitative Risk Assessment of Factors Affecting Construction Projects."IPASJ International Journal of Computer Science (IIJCS). Volume 4, Issue 5, May 2016.

Afshari, H., Khosravi, S., Ghorbanali, A., Borzabadi, M., & Valipour, M. (2010). Identification of causes of non-excusable delays of construction projects. Paper presented at the International Conference on E-business, Management and Economics.

Agarwal A., Shankar R. and Tiwari, M.K., Modeling agility of supply chain, Industrial Marketing Management, 36, 443- 457 (2006).

AGC. (2009). The Contractors Guide to Building Information Modelling. 2009. [Online] Available at www.agcnebuilders.com/documents/BIMGuide.pdf.

Ahbab Changiz. An Investigation on Time and Cost Overrun in Construction Projects. Master of Science in Civil Engineering. Thesis (M.S.)--Eastern Mediterranean University, Faculty of Engineering, Dept. of Civil Engineering, 2012.

Ahiaga-Dagbui, D, Smith, S D, Love, P E D and Ackermann, F (2015) Spotlight on construction cost overrun research: Superficial, replicative and stagnated In: Raidén, A B and Aboagye-Nimo, E (Eds) Procs 31st Annual ARCOM Conference, 7-9 September 2015, Lincoln, UK, Association of Researchers in Construction Management, 863-872.

Ahsan, K., & Gunawan, I. (2010). Analysis of cost and schedule performance of international development projects. International Journal of Project Management, 28(1), 68-78. doi: 10.1016/j.ijproman.2009.03.005.

AIA (2005). Intelligent building models and downstream use. Comments of the Technology in Architectural Practice Advisory Group submitted for the 2007 revisions to AIA Documents B141 and A201.

AIA California Council (2008): Integrated Project Delivery: Frequently Asked Questions

AIA, & AGC. (2011). Primer on project delivery second edition (pp. 15): The American Institute of Architects; The Associated General Contractors of America.

AIA, CC (2014). “Integrated Project Delivery: An Updated Working Definition”. THE AMERICAN INSTITUTE OF ARCHITECTS, CALIFORNIA COUNCIL.

AIA. (2007). Integrated project delivery: A guide.

AIA. (2004). Primer on project delivery: The American Institute of Architects; The Associated General Contractors of America.

Aibinu, A.A., & Jagboro, G.O. (2002). The effects of construction delays on project delivery in nigerian construction industry. International Journal of Project Management, 20, 7.

Ajamian, G. M., and P. A. Koen. 2002. “Technology Stage Gate: A Structured Process for Managing High-Risk New Technology Projects.” In P. Belliveau, A. Griffin, and S. Somermeyer, eds., The PDMA ToolBook for New Product Development. New York: John Wiley and Sons.

Ajamian, G. M., and P. A. Koen. 2002. “Technology Stage Gate: A Structured Process for Managing High-Risk New Technology Projects.” In P. Belliveau, A. Griffin, and S. Somermeyer, eds., The PDMA ToolBook for New Product Development. New York: John Wiley and Sons.

Al Zadjali, Zahra A., Hamdi A. Bashir, and Ali A. Maqrashi. "Factors Causing Project Cost Overrun in the Telecommunications Industry in Oman." International Journal of Information Technology Project Management (IJITPM) 5.3 (2014): 84-95.

Alaghbari, W.e., Kadir, M.R.A., Salim, A., & Ernawati. (2007). The significant factors causing delay of building construction projects in malaysia. Engineering, Construction and Architectural Management, 14(2), 192-206. doi: 10.1108/09699980710731308.

Alghonamy, A. (2015).Cost Overrun in Construction Projects in Saudi Arabia: Contractors‘ Perspective. International Journal of Engineering & Technology, IJET-IJENS, 15(4), 35-42.

Alinaitwe, Henry, Ruth Apolot, and Dan Tindiwensi. "Investigation into the causes of delays and cost overruns in Uganda's public sector construction projects." Journal of Construction in Developing Countries 18.2 (2013): 33.

Al-Khalil, M.I., & Al-Ghafly, M.A. (1999). Delay in public utility projects in saudi arabia. International Journal of Project Management, 17(2), 6.

Al-Momani, A.H. (1999). Construction delay: A quantitative analysis. International Journal of Project Management, 18, 9.

Amandin, Musirikare Mihigo, and Julius Warren Kule. "Project Delays on Cost Overrun Risks: A Study of Gasabo District Construction Projects Kigali, Rwanda." ABC Journal of Advanced Research 5.1 (2016): 21-34.

American Institute of Architects, National Association of State Facilities Administrators, Construction Owners Association of America, Association of

Higher Education Facilities Officers, Associated General Contractors of America, (2010). “Integrated Project Delivery For Public and Private Owners,” American Institute of Architects, Washington D.C.

American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc, 2009; An Introduction to Building Information Modeling (BIM).

Ashcraft, H. (2014). Integrated project delivery: Optimizing project performance. Hanson Bridgett LLP.

Ashcraft, Howard W. (2014). “Integrated project delivery: a prescription for an ailing industry.” Construction Law International . Dec2014, Vol. 9 Issue 4, p21-29. 9p.

Assaf, S.A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. International Journal of Project Management, 24(4), 349-357. doi: 10.1016/j.ijproman.2005.11.010.

Assaf, S.A., Al-Khalil, M., & Al-Hazmi, M. (1995). Causes of delay in large building construction projects. journal of Management in Engineering, 11(2), 7.

Associated General Contractors of America (AGC) (2004). Project Delivery Systems for Construction. AGC, Arlington, VA.

Associated General Contractors of America (AGC), 2009; Integrated Project Delivery: Collaboration through New Contract Forms.

Attri R., Grover S., Dev N. and Kumar D., An ISM approach for modelling the enablers in the implementation of Total Productive Maintenance (TPM), International Journal System Assurance Engineering and Management, DOI: 10.1007/s13198-012-0088-7 (2012).

Azis, Ade Asmi Abdul, et al. "Controlling cost overrun factors in construction projects in Malaysia." Research Journal of Applied Sciences, Engineering and Technology 5.8 (2013): 26212629.

Bain & Company. 2013. Roberto Nava and Tiziano Rivolta. “Large project management in oil and gas.” Bain & Company. Milan.

Barab, S. A., Cherkes-Julkowski, M., Swenson, R., Garrett. S., Shaw, R. E., and Young, M. F. (1999). Principles of selforganization: ecologizing the learner-facilitator system. J. Learn. Sci., 8(3/4), 349–390.

Barczak, G., Griffin, A., & Kahn, K. B. 2009. Trends and drivers of success in NPD practices: Results of the 2003 PDMA best practices study. Journal of Product Innovation Management, 26(1): 3–23.

Barnett-Page E, Thomas J: Methods for the synthesis of qualitative research: a critical review. BMC Med Res Methodol 2009, 9:59.

Barton, C. (2013). Execution of major capital projects in oil & gas. from http://oilpro.com/post/701/execution-of-major-capital-projects.

Beard, J., Loulakis, M., and Wundram, E. (2001). Design-Build: Planning Through Development, McGraw-Hill.

Bearup, W, Kenig, M., and O'Donnell, J. (2007). "Alternative Delivery Methods, a Primer", Proceedings, Airport Board Members and Commissioners Annual Conference, Airports Council International - North America, Chicago, IL.

Biljana STOŠIĆ, Radul MILUTINOVIĆ (2014). Possibilities Of Opening Up the Stage-Gate Model; Romanian Statistical Review nr. 4 / 2014.

Borse, Mandar, and Pranay Khare. "Analysis of Cost and Schedule Overrun in Construction Projects."IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 1, January 2016.ISSN 2348 – 7968.

BP. (2014). Bp statistical review of world energy june 2014 (pp. 48).

Bresnen, M. and Marshall, N. (2000). "Building Partnerships: Case Studies of Client-Contractor Collaboration in the UK Construction Industry." Construction Management and Economics, Volume 18, No.7, 819–832.

Brewer, J., & Hunter, A. (1989). Multimethod research: A synthesis of styles. Newbury Park, NJ: Sage.

Brunes, Fredrik, and Hans Lind. Explaining cost overruns in infrastructural projects: A new framework with applications to Sweden. No. 14/1. 2014.

Bushnell, T., Lehtinen, T., Kokkonen, A., Lavikka, R., Neelappa, A., Senescu, R., 2013. Collaboration and contracts in Integrated Project Delivery–Exploring the roles of owners and architects, in: The Boundary-Crossing Conference on Co-Design in Innovation. Presented at the Co-create, Espoo, Finland.

Butt, Gerald. "Oil and Gas in the UAE." United Arab Emirates: A new perspective (2001): 231-248.

Bygballe Lena E., Dewulf Geert, Levitt Ray E.(2014) "The interplay between formal and informal contracting in integrated project delivery". 13 December 2014 by Informa UK (Taylor & Francis) in Engineering Project Organization Journal. Engineering Project Organization Journal, Volume 5, pp 22-35; doi:10.1080/21573727.2014.992014.

Carr, W. (1997) Professing Education in a Postmodern Age, Journal of Philosophy of Education, 31, 2, 309-327.

Carrillo, Patricia, and Paul Chinowsky. "What Is So Integrated About Integrated Project Delivery? Exploring The Role Of Integration Mechanisms In IPD Projects." (2013).

Catherine Marshall & Gretchen B. Rossman (2006). Designing Qualitative Research. Thousands Oaks: Sage Publication, 262 pages (4th edition).

Chan, A. P. C., E. W. L. Cheng, and H. Li. Consultancy Report on Construction Partnering in Hong Kong. The Hong Kong Housing Society, 2001.

Chanmeka, A., Thomas, S.R., Caldas, C.H., & Mulva, S.P. (2012). Assessing key factors impacting the performance and productivity of oil and gas projects in alberta. Canadian Journal of Civil Engineering, 39(3), 259-270. doi: 10.1139/l11-128.

Cheng, E., Li, H., Love, P. and Irani, Z. (2004). "Strategic alliances: a model for establishing long-term commitment to inter-organizational relations in construction.” Building and Environment. Volume 39, Issue 4, 459–468.

Cheung, S. (2010). “Relational Contracting for Construction Excellence: Principles, Practices and Case Studies.” Construction Management and Economics. Volume 28, Issue 7, 805–806.

Chidambaram Ramanathan, S.N.a.A.B.I. (2012). Construction delays causing risks on time and cost - a critical review. Australasian Journal of Construction Economics and Building, 12, 21.

CMAA Owner’s Guide to Project Delivery Methods - August 2012; https://cmaanet.org/files/Owners Guide to Project Delivery Methods Final.pdf

CMAA. (2005). Fmi/cmaa sixth annual survey of owners.

Cohen, L., Manion, L., & Morrison, K. (2007) Research Methods in Education, 6th edition. London: Routledge.

Collis, J. & Hussey, R. (2009) Business Research: A practical guide for undergraduate and postgraduate students, 3rd edition, New York, Palgrave Macmillan.

Company, B. (2012). Executing capital projects in the mena energy industry much to learn, more to deliver: Booz & Company.

Cooper, R.G. (1990), Stage-Gate Systems - a New Tool for Managing New Products. Business Horizons, 33, 3 44-54.

Cooper, R. G. (1993). Winning at New Products, 2nd edition. Reading, MA: Addison- Wesley.

Cooper, R.G. (1994) Third-generation new product processes. Journal of Product Innovation Management, 11, 3–14.

Cooper, R. G. (1999). ‘From Experience: The Invisible Success Factors in Product Innovation’, Journal of Product Innovation Management, 16, pp. 115–133

Cooper, D.R.G. (2008). Perspective: The stage-gate idea-to-launch process – update, what’s new and nexgen systems. J. Product Innovation Management, 25(3), 213-232.

Cooper, R.G., and E.J. Kleinschmidt (1986). An Investigation into the New Product Process: Steps, Deficiencies, and Impact. The Journal of Product Innovation Management, 3(2), 71-85.

Cooper, R.G. and E. J. Kleinschmidt (1990): New products - the key factors in success, Chicago ; American Marketing Association.

Cooper, R.G., Edgett, S.J. and Kleinschmidt, E.J. (1999). New Product Portfolio Management: Practices and Performance. Journal of Product Innovation Management (16)4:333 -351 (July).

Cooper, R.G., NexGen Stage-Gate ® —What Leading Companies Are Doing to Re-Invent Their NPD Processes, PDMA Visions, XXXII, No 3, Sept. 2008, pp. 6-10.

Crawford, C. Merle (1994), New Products Management. Burr Ridge: Irwin.

Creedy, Garry D., Skitmore, Martin. & Wong, Johnny K. W. (2010), “Evaluation of Risk Factors Leading to Cost Overrun in Delivery of Highway Construction Projects”, Journal of Construction Engineering and Management, Vol. 136, No. 5, 528-537.

Creswell, J.W. (2003). Research design: Qualitative, quantitative, and mixed methods approaches (2nd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2005). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (2nd ed.). Upper Saddle River, NJ: Pearson Education.

Creswell, J. W. (2009). Research design: Qualitative, quantitative, and mixed methods approaches, 3rd ed. Thousand Oaks, CA: SAGE Publications.

Cudney, Gary (2006). The pros and cons of Design-Build. International Parking Institute. http://www.carlwalker.com/wp-content/uploads/2012/09/Pros-Cons-of-Design-Build.pdf.

Daniel Amaral Fernandes, Pertti Lahdenperä and António Aguiar Costa; University of Salford 2014, Suitability of Project Alliancing for a Customary Apartment Renovation – A Case Study.

Dantata, Nasiru A., Ali Touran, and Donald C. Schneck. "Trends in US rail transit project cost overrun." Transportation Research Board (2006).

Deloitte. (2013). The challenge of renaissance managing an unprecedented wave of oil and gas capital projects (pp. 24).

Denni-Fiberesima D. and Rani N.S.A. (2011). An Evaluation of Critical Success Factors in Oil and Gas Project Portfolio in Nigeria, African Journal of Business Management, Vol. 5(6), 18 March, p. 13.

Denscombe, M. (2007) The good research guide : for small-scale social research projects. Maidenhead, England ; New York: Open University Press.Design Build Intitute of America (DBIA), 2015: https://www.dbia.org/about/Documents/db_primer_choosing_delivery_method.pdf

Deszca, G., Munro, H., Noori, H., 1999. Developing breakthrough products: challenges and options for market assessment. Journal of Operations Management 17, 613–630.

DIT (2011). “National Alliance Contracting Guidelines. Guide to Alliance Contracting.” Australian Government, Department of Infrastructure and Transport. Canberra, Australia. DTF.

Doloi, H., Sawhney, A., Iyer, K.C., & Rentala, S. (2012). Analysing factors affecting delays in indian construction projects. International Journal of Project Management, 30(4), 479-489. doi: 10.1016/j.ijproman.2011.10.004.

Douglas G. Bock, "Axiology & Rhetorical Criticism: Some Dimensions of the Critical Judgment," Western Speech 37 (Spring 1973): 87-96.

Dr Patrick. X.W. Zou1, D.G.Z.a.P.J.-Y.W. (2006). Identifying key risks in construction projects: Life cycle and Stakeholder perspectives. Paper presented at the 12th Pacific Rim Real Estate Society Conference, Auckland, New Zealand,.

Dr. Joseph A. Wright (2012) “The Integration of Building Information Modeling and Integrated Project Delivery in to the Construction Management Curriculum”. American Society for Engineering Education.

Dr. Kris R. Nielsen. (2007). Current Risk Management Issues in the Oil & Gas Industry. 2007 Deutsche Bank Oil & Gas Conference. London, UK – 27 September 2007.

DTF (2006). “Project Alliancing: Practitioners’ Guide.” The Department of Treasury and Finance. Melbourne, Australia.

Easterby-Smith, M., Thorpe, R. and Jackson, P. (2012, 4th Edn) Management Research. London: Sage.

Ed J. Nijssen, Karin F.M. Lieshout, (1995) "Awareness, use and effectiveness of models and methods for new product development", European Journal of Marketing, Vol. 29 Iss: 10, pp.27 – 44.

Edgar S. Brightman and Robert N. Beck, An Introduction to Philosophy (New York: Holt, Rinehart and Winston, Inc., 1963), p. 330.

El Asmar, M., Hanna, A.S., Loh, W.-Y., 2013. Quantifying Performance for the Integrated Project Delivery System as Compared to Established Delivery Systems. J. Constr. Eng. Manag. 139, 04013012. doi:10.1061/(ASCE)CO. 1943-7862.0000744.

El Asmar, Mounir and Hanna, Awad S. (2012). Comparative Analysis of Integrated Project Delivery (IPD) Cost and Quality Performance.

El Wardani, M., Messner, J.I., Horman, M.J., 2006, ‘Comparing procurement methods for design-build projects’, ASCE Journal of Construction Engineering and Management 132(3), 230 –238.

Eliezer Salami (2012). “Introduction Of Integrated Project Delivery and Likely Impacts on Pretender Cost Management in Ghana”. Master Thesis. HFT Stuttgart.

El-Razek, M.E.A., Bassioni, H.A., & Mobarak, A.M. (2008). Causes of delay in building construction projects in egypt. Journal of Construction Engineering and Management, 134(11), 12. doi: 10.1061//asce/0733-9364/2008/134:11/831.

El-Shehaby, Mohamed, Ibrahim Nosair, and Abd El-Moniem Sanad. "RISK ASSESSMENT AND ANALYSIS FOR THE CONSTRUCTION OF OFF SHORE Oil & GAS PROJECTS." International Journal Of Scientific Research And Education 2.02 (2014).

ENR, Engineering News-Record (2011). “ United they Build”.

Ettlie, J, and J M Elsenbach. (2006) “Scale, R&D Performance and Idea Profiles for New Products: A Comparative Study of U.S. and German Manufacturing Firms. Journal of Global Business and Technology Fall 2006; 2, p.1-25.

Everitt, N. and A. Fisher: 1995, Modern Epistemology: A New Introduction,McGraw-Hill, New York, London.

EY. (2014). Spotlight on oil and gas megaprojects: Ernst & Young Global Limited.

EY (2015). Improving project delivery in oil and gas: managing the megaprojects. Extract from Performance, Volume 7, Issue 3, August 2015.

Faizatul Akmar Abdul Nifa, Mohd Nasrun Mohd Nawi, Suria Musa and Wan Nadzri Osman (2015) “Integrated Project Delivery Framework For Sustainable Campus Development: A Qualitative Study On JPP UUM”. 5th International Conference on Computing and Informatics.

Fallahnejad, M.H. (2013). Delay causes in iran gas pipeline projects. International Journal of Project Management, 31(1), 136-146. doi: 10.1016/j.ijproman.2012.06.003.

Faridi, A.S., & El-Sayegh, S.M. (2006). Significant factors causing delay in the uae construction industry. Construction Management and Economics, 24(11), 1167-1176. doi: 10.1080/01446190600827033.

Farris D.R. and Sage A.P., On the use of interpretive structural modeling for worth assessment, Computer and Electrical Engineering, 2, 149–174 (1975).

Fayek, A.R., Revay, S.O., Doug Rowan, & Mousseau, D. (2006). Assessing performance trends on industrial construction mega projects. Cost Engineering, 48(10), 16-21.

Fellows, R. & Liu, A. (2008) Research methods for construction, 3rd ed, Chichester, WileyBlackwell.

Fernane, James David, "Comparison of design-build and design-bid-build performance of public university projects" (2011). UNLV

Theses/Dissertations/Professional Papers/Capstones. Paper 1210.

Fish, Amanda (2011). Integrated Project Delivery: The Obstacles of Implementation. Department of Architectural Engineering and Construction Science. KANSAS STATE UNIVERSITY. https://krex.k-state.edu/dspace/bitstream/handle/2097/8554/AmandaFish2011.pdf?sequence=1.

Flyvbjerg, Bent, Mette K. Skamris Holm, and Søren L. Buhl. "What causes cost overrun in transport infrastructure projects?." Transport reviews 24.1 (2004): 3-18.

Fredrick Lewis and Mehmet E. Ozbek, (2015). “Electrical Contractors and Integrated Project Delivery”. 51st ASC Annual International Conference Proceedings.

Friedlander C. Mark. Schiff Hardin LLP. Advantages of Integrated Project Delivery. http://www.schiffhardin.com/Templates/media/files/publications/PDF/Benefits_from_Integrated_Project_Delivery.pdf.

Frimpong, Y., Oluwoye, J., & Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in a developing countries; ghana as a case study. International Journal of Project Management, 21(5), 321-326. doi: 10.1016/s0263-7863(02)00055-8.

Fuller, Gordon W., “New Food Product Development: From Concept to

Marketplace", CRC Press, Montreal, Quebec, 1994.

Gaba, G. (2013). The impact of project delivery systems, cost minimisation and project control on construction project success. Evidence from ghana.

Gary Aller, Alliance for Construction Excellence & RH & Associates, Inc. (2008): http://www.value-eng.org/pdf_docs/2008GMConference/6_APDM_Hoekstra.pdf.

Gasasira, Innocent, Peter MBABAZI, and Eugene Ndabaga. "THE CAUSATIVE FACTORS LEADING TO COST OVERRUN IN DAM CONSTRUCTION PROJECTS IN RWANDA: CASE STUDY KINONI 1 DAM CONSTRUCTION PROJECT." European Journal of Business and Social Sciences 4.11 (2016): 142-168.

Graham, P. (2001). "Evaluation of design-build practice in Colorado." IR (CX) 70-4 (143), Colorado DOT, Denver.

Gransberg, D.D., J.S. Shane, and J. Ahn, (2011) "A Framework for Guaranteed Maximum Price and Contingency Development for Integrated Delivery of Transportation Projects," Journal of Construction Engineering and Project Management, KICEM, Vol. 1, (1), pp. 1-10.

Green, G., Kennedy, P., and McGown, A. (2002). "Management of Multi-

method Engineering Design Research: A Case Study." Journal of Engineering

and Technology Management, 19(2), 131-140.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989) "Toward a Conceptual Framework for Mixed-method Evaluation Designs". Educational Evaluation and Policy Analysis, Vol 11, No. 3, pp 255-274.

Guba, E.G. and Lincoln, Y. S. (1994), "Competing Paradigms in Qualitative Research", in: N.K. Denzin and Y.S. Lincoln (ed.), Handbook of Qualitative

Research, Sage Publication, London.

Guba, E. G., & Lincoln, Y. S. (1998). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.). The landscape of qualitative research: Theories and issues (pp.195-220). Thousand Oaks, CA: Sage.

H. W. Ashcraft, "Negotiating an Integrated Project Delivery Agreement," Hanson Bridgett, San Francisco, 2010.

Hajiagha Seyed Hossein Razavi et. al. (2016). "Success Criteria in Oil, Gas and Petrochemical Projects". Conference: 2016 International Conference on Electrical, Mechanical and Industrial Engineering. DOI: 10.2991/icemie-16.2016.60.

Hamzah, N., Khoiry, M.A., Arshad, I., Tawil, N.M., & Che Ani, A.I. (2011). Cause of construction delay - theoretical framework. Procedia Engineering,

20, 490-495. doi: 10.1016/j.proeng.2011.11.192.

Han, S.H., Yun, S., Kim, H., Kwak, Y.H., Park, H.K., & Lee, S.H. (2009). Analyzing schedule delay of mega project: Lessons learned from korea train

express. IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, 56(NO.

2,), 14.

Harding, Sandra. 1987b. “Conclusion: Epistemological Questions.” Pp. 181–90 in Feminism and Methodology, edited by S. Harding. Bloomington: Indiana University Press.

Haron, A.T. (2013). Organisational readiness to implement building information modelling: A framework for design consultants in malaysia. (University of Salford Manchester), University of Salford Manchester.

Hasan M.A., Shankar R. and Sarkis J., A study of barriers to agile manufacturing, International Journal of Agile System and Management, 2(1), 1-22 (2007).

Haseeb, M., Xinhai-Lu, Bibi, A., Maloof-ud-Dyian, & Rabbani, W. (2011). Problems of projects and effects of delays in the construction industry of pakistan. Australian Journal of Business and Management Research, 1(5), 10.

Hauser, J., Tellis, G. J., & Griffin, A. (2006, November-December). Research on Innovation: A Review and Agenda for Marketing Science. Marketing Science , 687- 717.

Hesse-Biber, S. N., & Leavy, P. (2004). Distinguishing qualitative research. In S. N. Hesse-Biber & P. Leavy (Eds.), Approaches to qualitative research: A reader on theory and practice (pp. 1–15). New York: Oxford University Press.

Hinchey W. John (2013) “Avoiding Construction Conflicts and Disputes with Integrated Project Delivery (IPD)”. Navigant Consulting, Inc.

Hornby, A.S. et.al.(1975). The Advances Learner’s Dictionary to Current English.SecondEdition. London: Oxford University Press.

http://www.findorff.com/assets/pdf/DeliveryMethods.pdf.

Hughes, G. D./ Chafin, D. C. (1996): „Turning New Product Development into a Continuous Learning Process”, in: Journal of Product Innovation Management, Jg. 13, S. 89-104.

Ibbs, C. W., Kwak, Y. H., Ng, T., and Odabasi, M. 2003. “Project delivery systems and project change: Quantitative analysis.” J. Constr. Eng. Manage., 1294, 382–387.

IEA. (2014). World energy investment outlook.

Ilozor, B.D., & Kelly, D.J. (2011). Building Information Modeling and Integrated Project Delivery in the Commercial Construction Industry: A Conceptual Study. Journal of Engineering, Project, and Production Management, 2(1), 23-36.

Ismail, Alaa Ahmad Mohammad. TIME AND COST OVERRUN IN PUBLIC CONSTRUCTION PROJECTS IN QATAR. Diss. QATAR UNIVERSITY, 2014.

Iyer, K.C., Chaphalkar, N.B., & Joshi, G.A. (2008). Understanding time delay disputes in construction contracts. International Journal of Project

Management, 26(2), 174-184. doi: 10.1016/j.ijproman.2007.05.002

Jefferies, M. Graham, B., Rowlinson, S., Cheung, Y. and Satchell, A. (2006). “Project alliances in the Australian construction industry: a case study of a water treatment project.” Symposium on CIB W92: sustainability and value through construction procurement.

Jergeas, George. "Improving construction productivity on Alberta oil and gas capital projects." A report submitted to Alberta Finance and Enterprise, University of Calgary, Alberta, Canada (2009).

Jharkharia S. and Shankar R., IT- Enablement of supply chains: Understanding the barriers, Journal of Enterprise Information Management, 18(1), 11-27 (2005).

Jick, T. D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. Administrative Science Quarterly, 24, 602-611.

Joel W. Darrington (2014) “Key Elements of a Lean Integrated Project Delivery Project”. CMAA Northern California Chapter. Presentation.

Jonassen, D. H. (1991). Objectivism versus constructivism: do we need a new philosophical paradigm? Educ. Technol. Res. Dev., 3(93), 5–14.

Jones, B., 2014. Integrated Project Delivery (IPD) for Maximizing Design and Construction Considerations Regarding Sustainability. Procedia Engineering, 95, pp.528–538.

Kadiri, Dele Samuel, and Anthony Abiodun Shittu.(2015) "CAUSES OF TIME OVERRUN IN BUILDING PROJECTS IN NIGERIA: CONTRACTING AND CONSULTING PERSPECTIVES."International Journal of Civil Engineering, Construction and Estate Management Vol.3, No.4, pp.50-56, October 2015.

Kagioglou, M., Cooper, R., Aouad, G., & Sexton, M. (2000). Rethinking construction: The generic design and construction process protocol. Engineering, Construction and Architectural Management, 7(2), 141-153. doi: 10.1108/eb021139.

Kaliba, C., Muya, M., & Mumba, K. (2009). Cost escalation and schedule delays in road construction projects in zambia. International Journal of Project Management, 27(5), 522-531. doi: 10.1016/j.ijproman.2008.07.003.

Kaming, P.F., Olomolaiye, P.O., Holt, G.D., & Harris, F.C. (1997). Factors influencing construction time and cost overruns on high-rise projects in indonesia. Construction Management and Economics, 15, 14.

Kent, D. C. & Becerik-Gerber, B. (2010, August). Understanding construction industry experience and attitudes toward integrated project delivery. Journal of Construction Engineering and Management.

Kessler, F. (2005). “Managing Your Money: Project Delivery Methods.” MassTransit, April 2005, 26–39. http://www.nossaman.com/showarticle.aspx?show=913 (accessed March 20, 2007).

Khan Shehzad (2015). AN ANALYSIS ON CRITICAL CAUSES OF DELAYS IN OIL & GAS CONSTRUCTION PROJECTS. PMI National Conference, INDIA, September 10-12, 2015.

King, T. D. "Assessment of problems associated with poor project management performance." (2013).

Konchar, V.S.M. (1999). Selecting project delivery systems: The Project Delivery Institute.

KPMG (2012) Study on Project schedule and cost overruns, KPMG, Project Management India and Ministry of Statistics and Programme Implementation, Nov 2012.

KPMG, 2013: Integrated Project Delivery: Managing risk and making it work for all parties: https://www.kpmg.com/US/en/IssuesAndInsights/ArticlesPublications/Documents/integrated-project-delivery-whitepaper.pdf.

Kristen Parrish. (2012). "A Path to Successful Energy Retrofits: Early Collaboration through Integrated Project Delivery Teams" Environmental Energy Technologies Division. U.S. Department of Energy.

Kumaraswamy, M.M., & Chan, D.W.M. (1998). Contributors to construction delays. Construction Management and Economics, 16(1), 17-29. doi: 10.1080/014461998372556.

Kuo, Y.-C., & Lu, S.-T. (2013). Using fuzzy multiple criteria decision making approach to enhance risk assessment for metropolitan construction projects. International Journal of Project Management, 31(4), 602-614. doi: 10.1016/j.ijproman.2012.10.003.

L. M. (Ed.). (2008). The SAGE encyclopedia of qualitative research methods. Thousand Oaks, CA: SAGE Publications, Inc. doi: http://dx.doi.org/10.4135/9781412963909.

Lahdenperä, P. (2011). "Towards the Use of Project Alliance: Joint Development of a team Selection Procedure as an Example of Steps Taken." In: Management and Innovation for a Sustainable Built Environment. Amsterdam, The Netherlands.

Larry Johnson & Mike Zeltner (2012). PNCWA. Building Professional Excellence in Water Quality Annual conference and Exhibition. The Alternative of Alternative Delivery: Progressive Design Build. http://www.pncwa.org/assets/2012Conf/Presentations/Session_21A_Alternative_Delivery/johnson_zeltner_alternative_delivery.pdf.

Lawson, T. (2004). Reorienting economics: On heterodox economics, themata and the use of mathematics in economics. Journal of Economic Methodology, 11(3), 329-340. doi: 10.1080/1350178042000258536.

Lee, Christopher S. (2013). Implementation of Integrated Project Delivery on Department of Navy Military Construction Projects, Master Thesis, University of Nevada, Las Vegas, pg. 10.

Le-Hoai, L., Lee, Y.D., & Lee, J.Y. (2008). Delay and cost overruns in vietnam large construction projects: A comparison with other selected countries. KSCE Journal of Civil Engineering, 12(6), 367-377. doi: 10.1007/s12205-008-0367-7.

Leicht, R. M., Molenaar, K. R., Messner, J. I., Franz, B. W., and Esmaeili, B.

(2015). Maximizing Success in Integrated Projects: An Owner's Guide.

Version 0.9, May.

Lester Thonssen, A. Craig Baird, and Waldo W. Braden, Speech Criticism, 2iid ed. (New York, 1970), p. 19.

Lombardo, T. J. (1987). The Reciprocity of Perceive and Environment: The Evolution of James J. Gibson's Ecological Psychology. Hillsdale, NJ: Lawrence Erlbaum Associates.

Long, R.J. (2014). Typical problems leading to delays, cost overruns, and claims on process plant and offshore oil & gas projects: Long International. inc.

Lu, S. and Yan, H. (2007). "An empirical study on incentives of strategic partnering in China: Views from construction companies." International Journal of Project Management. Volume 25, Issue 3, 241–249.

M, S., P, L., & A, T. (2011). Research methods for business students.

Mack, L. (2010). The philosophical underpinnings of educational research. Polyglossia, 19, 1-11.

Mackenzie, W and Cusworth, N, 2007. The use and abuse of feasibility studies, Project Evaluation Conference, Melbourne.

Mahamid, Ibrahim, and Nabil Dmaidi. "Risks Leading to Cost Overrun in Building Construction from Consultants' Perspective." Organization, Technology & Management in Construction: An International Journal 5.2 (2013): 860-873.

Mahamid, Ibrahim. "Frequency of time overrun causes in road construction in

Palestine: Contractors' View." Organization, Technology & Management in

Construction: An International Journal 5.1 (2013): 720-729.

Majld, M.z.A., & McCaffer, R. (1998). Factors of non-excusable delays that influence contractors' performance. Journal of Management in Engineering, 14(3), 10.

Martin Fischer, Dean Reed, Atul Khanzode and Howard Ashcraft. (2014). "A Simple Framework for Integrated Project Delivery". Proceedings IGLC-22, June 2014. Oslo, Norway.

Marzouk, M.M., & El-Rasas, T.I. (2014). Analyzing delay causes in egyptian construction projects. Journal of Advanced Research, 5(1), 49-55. doi: 10.1016/j.jare.2012.11.005.

Mashayekhi Ali N., & Mazaheri Tahmasb, a.Y.F. (2010). Dynamic analysis of petrochemical project progress - a system dynamics. Paper presented at the International Conference on Industrial Engineering and Operations Management, Dhaka, Bangladesh.

Masucci R Maurice (2008). Hill International, Inc. Project Delivery Systems: Pro vs. Con Design-Bid-Build vs. CM @ Risk vs. Design-Build. http://www.cmaasc.org/pdfs/article_archives/project_1j.pdf.

McGrath, M. E. 1996. "The Phase Review Process and Effective Decision Making." In M. E. McGrath, ed., Setting the PACE in Product Development. Boston: Butter-worth and Heinemann.

McKenna, Matthew G., Herve Wilczynski, and David VanderSchee. "Capital project execution in the oil and gas industry." Booz Allen Hamilton, Houston (2006).

Memon, Aftab Hameed, et al. "The cause factors of large project's cost overrun: a survey in the southern part of Peninsular Malaysia." International Journal of Real Estate Studies (INTREST) 7.2 (2014).

Merrow, E.W. (2003). Mega field developments require special tactics, risk management. Offshore Magazine.

Merrow, E.W. (2012). Oil and gas industry megaprojects: Our recent track

record. Society of Petroleum Engineers.

Meurer WJ, Frederiksen SM, Majersik JJ, Zhang L, Sandretto A, Scott PA. Qualitative data collection and analysis methods: the INSTINCT trial. Acad Emerg Med 2007;14:1064–1071.

Millward, Huw and Alan Lewis (2005), "Barriers to Successful New Product Development within Small Manufacturing Companies," Journal o f Small Business and Enterprise Development, 12 (April), 379-94.

Mistry, D and Davis, P R (2009) A client's perspective of critical success factors in project alliances. in: Dainty, A.R.J. (Ed) Procs 25th Annual ARCOM Conference, 7-9 September 2009, Nottingham, UK, Association of Researchers in Construction Management, 217-26.

Mitchell, B.P. (1999). The applicability of the spearin doctrine: Do owners warrant plans and Specifications? FindLaw for Legal Professionals.

MJ Mukuka (2014). A Theoretical Review of the Causes and Effects of Construction Projects Cost and Schedule Overruns. International Conference on Emerging Trends in Computer and Image Processing (ICETCIP'2014) Dec. 15-16, 2014 Pattaya (Thailand).

Molda, David (2009). Design-Build Institute of America. Finance & Commerce Publication dated 18 December 2009. http://www.dbia-um.org/docs/Design_Build_Advantage_Time_Cost_and_Responsibility_December_19_2009.pdf.

Mollaoglu-Korkmaz S, Miller VD, Sun W. Assessing key dimensions to effective innovation implementation in interorganizational project teams: an Integrated Project Delivery case. Engineering Project Organization Journal 2013. Advance online publication. doi:10.1080/21573727.2013.855895.

Morris, Sebastian. "Cost and time overruns in public sector projects." Economic and Political weekly (1990): M154-M168.

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. Nursing Research, 40, 120-123.

Morse, J. M. (2003). Principles of mixed methods and multimethod research design. In A. Tashakori, & C. Teddlie, Handbook of mixed methods in social and behavioural research (pp. 189-208). Thousand Oaks, CA: Sage.

Mortaheb, M.M., Amini, Y., Younesian, A.H., & Soltani, P. (2013). Impacts of engineering work quality on project success. Procedia - Social and Behavioral Sciences, 74, 429-437. doi: 10.1016/j.sbspro.2013.03.021.

Nabil A. Kartam, S.A.K. (2000). Risk and its management in the kuwaiti construction industry: A contractors' perspective. International Journal of Project Management, 19, 11.

Nasierowsk, W. (2008). Project development: Why does it really matter to companies? Institute of Organization and Managment in Industry, 1(1), 63-68.

Nava Roberto and Rivolta Tiziano (2013). Large Project Management in Oil and Gas. Bain & Company.

Nega, Fetene. Causes and effects of cost overrun on public building construction projects in Ethiopia. Diss. aau, 2008.

Nofera, W., Korkmaz, S., & Miller, V. D. (2011). Innovative features of integrated project delivery shaping project team communication. The 2011 Engineering Project Organizations Conference. August 9-11, 2011, Denver, CO.

North Carolina State Construction Office. (2005). “Construction Management-At-Risk Selection Procedures”, [WWW document] URL http://interscope2.doa.state.nc.us/Guidelines/CM@RISK%20SELECTION%20PROCEDUR ES.pdf (Visited 2005, January 31).

Obawole, A. B. "An examination of performance models in execution of major upstream oil and gas projects in Nigeria." Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 3.2 (2012): 349-353.

Odeh, A.M., & Battaineh, H.T. (2002). Causes of construction delay: Traditional contracts. International Journal of Project Management, 20, 7.

Ogunlana, S.O., Promkuntong, K., & Jearkjirm, V. (1996). Construction delays in a fast-growing economy: Comparing thailand with other economies. International Journal of Project Management, 14(1), 9.

Orangi, A., Palaneeswaran, E., & Wilson, J. (2011). Exploring delays in victoria-based astralian pipeline projects. Procedia Engineering, 14, 874-881. doi: 10.1016/j.proeng.2011.07.111.

Patrick Duke, Steve Higgs, McMahon R. William (2010) Integrated Project

Delivery: “The Value Proposition”. An Owner’s Guide for Launching a Healthcare Capital Project via IPD.

Patrick. J. O’Conner, ‘Integrated Project Delivery: Collaboration Through New Contract Forms’ (Faegre & Benson, LLP, 2009): 23.

Patton, M. Q. (1990). Qualitative evaluation and research methods. Thousasnd Oaks, CA: Sage.

Peter Raisbeck et. Al, 2010. Assessing Integrated Project Delivery: A Comparative Analysis of IPD and Alliance Contracting Procurement Routes.

Pittaway, L., M. Robertson, K. Munir, D. Denyer and A. Neely. (2004). Networking and innovation: a systematic review of the evidence. International Journal of Management Reviews, 5-6(3-4), 137-168.

Poonam Raykar, Ghadge A.N. (2016). Analyzing the Critical Factors Influencing the Time Overrun and Cost Overrun in Construction Project.

International Journal of Engineering Research Volume No.5, ISSN:2319-

6890(online),2347-5013(print)doi : 10.17950/ijer/v5i1/006.

Rahimi Zahra , Keramati Ali Mohammad, Javanmard Habibollah. "Identifying the Causes of Delay in Projects of Phase 15 and Phase 16 of South Pars GasField Using TOPSIS Method". Journal of Applied Environmental and Biological

Sciences. ISSN: 2090-4274. J. Appl. Environ. Biol. Sci., 5(11S)924-934, 2015.

Raisbeck, P., Millie, R., & Maher, A. (2010). Assessing Integrated Project Delivery: A Comparative Analysis of IPD And Alliance Contracting Procurement Routes. Paper presented at the 26th Annual ARCOM Conference, UK.

Raj T., Shankar R. and Suhaib M., An ISM approach for modeling the enablers of flexible manufacturing system: The case for India, International Journal of Production Research, 46(24), 1-30 (2007).

Raj T. and Attri R., Identification and modelling of barriers in the implementation of TQM, International Journal of Productivity and Quality Management, 28(2), 153-179 (2011).

Raj T., Attri R. and Jain V., Modelling the factor affecting flexibility in FMS, International Journal of Industrial and System Engineering, 11(4), 350-374 (2012).

Ramanathan Chidambaram, and Narayanan Sambu Potty(2014), “Qualitative analysis of Time delay and Cost overrun in Multiple Design and Build Projects” International Conference Data Mining, Civil and Mechanical Engineering (ICDMCME’2014), Feb 4-5, 2014 Bali (Indonesia).

Ramanathan, C., Narayanan, S., & Idrus, A.B. (2012). Construction delays causing risks on time and cost - a critical review. Australasian Journal of Construction Economics and Building, 12(1), 37-57.

Ravi V. and Shankar R., Analysis of interactions among the barriers of reverse

logistics. Technological Forecasting and Social Change, 72, 1011-1029

(2005).

Ravi V., Shankar R. and Tiwari M.K., Productivity improvement of a computer hardware supply chain, International Journal of Production and Performance

Measurement, 54(4), 239-255 (2005).

Reber, A. S. (1995). The Penguin Dictionary of Psychology. New York: Penguin Books.

Renée Cheng, (2015). “INTEGRATION AT ITS FINEST: Success in High-Performance Building Design and Project Delivery in the Federal Sector”. Research Report.

Renée Cheng, (2015). “IPD: Performance, Expectations, and Future Use”.

University of Minnesotoa.

Richardson, Michael D., "Contractually Altering Integrated Project Delivery's Success" (2012). Senior Honors Theses. Eastern Michigan University.

Ronald D. Ciotti, Hinckley, and Seth M Pasakarnis. CIM Construction Journal.

Ross, Jim (2003). “Introduction to Project Alliancing”. Alliance Contracting Conference, Sydney, Australia.

Rothwell R., Soete L. (1983). Technology and Economic Change // Physics in Technology, Vol. 14, No. 6, November, pp. 270–277.

Rummel, Francis J., and Ballaine, Wesley C. Business. New York: Harper & Research Methodology in Row Publishes, 1963.

Ryan T. Manning (2012) “Challenges, Benefits, & Risks Associated with Integrated Project Delivery and Building Information Modeling”. Engineering Management Field Project. University of Kansas.

Sage A.P., Interpretive structural modeling: Methodology for large scale systems, New York, NY: McGraw-Hill (1977).

SAIC, AECOM Consult, University of Colorado at Boulder, Design-Build Effectiveness Study, Final Report, Federal Highway Administration, January 2006.

Salama, M., Hamid, M.A.E., & Keogh, B. (2008). Investigating the causes of delay within oil and gas projects in the u.A.E. Paper presented at the Annual ARCOM Conference, Cardiff, UK.

Salerno, Jim and Holmes, Hillary (2015). MWH Constructors. Construction Management at Risk. NWOWEA Pre-Conference Utility Workshop. http://www.ohiowea.org/docs/06_22_1100_3-SalernoJ_CMAR.pdf.

Samarghandi, Hamed, et al. "Studying the Reasons for Delay and Cost Overrun in Construction Projects: The Case of Iran." Journal of Construction in Developing Countries (in press) (2016).

Sambasivan, M., & Soon, Y.W. (2007). Causes and effects of delays in malaysian construction industry. International Journal of Project Management, 25(5), 517-526. doi: 10.1016/j.ijproman.2006.11.007.

Sandelowski M. Combining qualitative and quantitative sampling, data collection, and analysis techniques in mixedmethod studies. Res Nurs Health. 2000;23:246-256.

Saunders, M. et al (2012) Research methods for business students, 6th

edition, London: Financial Times Prentice Hall.

SBC. (2012). Challenges of e&p megaproject delivery.

Schelker, T (1976). Problem Solving Methods in the New Product Development Process (in German). Bern: Verlag Paul Haupt.

Shapiro S. Bryan (2013). Shapiro Hankinson & Knutson Law Corporation.

Design/Build and Turnkey contracts – Advantages and Disadvantages.

http://www.shk.ca/wp/wp-content/uploads/2013/02/Design-Build-and-Turnkey-

Contracts-Advantages-and-Disadvantages.pdf.

Sharp, H., Finkelstein, A., & Galal, G. (1999). Stakeholder identification in the

requirements engineering process.

Siemiatycki, Matti. A Cost Overruns On Infrastructure Projects: Patterns,

Causes And Cures. Toronto: Institute on Municipal Finance and Governance,

2016.

Simms, Chris (2012). An analysis of the management of packaging within new product development: an investigation in the UK food and drinks sectors. PhD thesis, University of Portsmouth.

Singh M.D., Shankar R., Narain R. and Agarwal A., An interpretive structural modeling of knowledge management in engineering industries, Journal of Advances in Management Research, 1(1), 28–40 (2003).

Skeggs, Chris (2001) Project Partnering in the international Construction industry. FIDIC. Localised at www1.fidic.org/resources/contracts/skeggs.asp on 3 Jan 2007.

Soiferman, L.K. (2010). Compare and Contrast Inductive and Deductive Research Approaches. Manitoba: University of Manitoba.

Sovacool BK, Nugent D, Gilbert A. An international comparative assessment of construction cost overruns for electricity infrastructure. Energy Research & Social Science, 2014; 3:152–160.

Stage Gate International. http://www.stage-gate.com/resources_stage-gate_full.php.

State of Alaska - Department of Education & Early Development, 2004; Project Delivery Method Handbook: https://education.alaska.gov/facilities/publications/project_delivery_handbook.Pdf.

Suda, Khairul Azizan, et al. "A Review on Risks and Project Risks

Management: Oil and Gas Industry." International Journal of Scientific &

Engineering Research, Volume 6, Issue 8, August-2015. ISSN 2229-5518.

Sullivan Todd (2015). “Creating Value Through IPD – Integrated Project Delivery”. The Morse Group.

Sullivan, A., & Harris, F.C. (1986). Delays on large construction projects. International Journal of Operations & Production Management, 6(1), 25-33. doi: 10.1108/eb054752.

Sunjka, B.P. and Jacob, U. (2013). Significant causes and effects of project delays in the Niger delta region, Nigeria. SAIIE25 Proceedings: Stellenbosch, South Africa © 2013 SAIIE.

Sweis, G., Sweis, R., Abu Hammad, A., & Shboul, A. (2008). Delays in construction projects: The case of jordan. International Journal of Project Management, 26(6), 665-674. doi: 10.1016/j.ijproman.2007.09.009.

Swink, M.L. (1998), “A tutorial on implementing concurrent engineering in new product development programs”, Journal of Operations Management, Vol. 16 No. 1, pp. 103-16.

Sylvester, Dicky Cassily, Nazatul Shima Abdul Rani, and Nazatul Shima. "Theoretical Framework: Factors for Project Success in Oil & Gas Companies & Contractors in Miri, Sarawak, Malaysia." (2010).

Tang, L., Shen, Q. and Cheng, E. (2010). “A review of studies on Public–Private Partnership projects in the construction industry.” International Journal of Project Management. Volume 28, Issue 7, 683–694.

Taylor J. Mark, PhD, JD and Olsen, Darren A. (2012) “Integrated Project Delivery: Not a Panacea for Everyone”. 48th ASC Annual International Conference Proceedings.

Thornhill, A., Lewis, P. & Saunders, M. (2012). Research methods for

business students. Sixth Edition. Harlow: Pearson educated limited.

Tony Lawson. (2004). A Conception of Ontology. Faculty of Economics, Cambridge. United Kingdom.

Transit Cooperative Research Program (TCRP) Report 131: 2009: A Guidebook for the Evaluation of Project Delivery Methods: http://www.tcrponline.org/PDFDocuments/TCRP_RPT_131.pdf.

Trauner Consulting Services, Inc. (2007). Construction Project Delivery Systems and Procurement Practices: Considerations, Alternatives, Advantages and Disadvantages. http://www.fefpa.org/pdf/summer2007/Pros-Cons-handout.pdf.

Travis R. Johnson (2011) Department Of The Air Force Air University. Air Force Institute of Technology. Application of Relational Contracting Methods to Federal Construction Projects.

Trott, P. (2008). Innovation management and new product development Harlow, Financial Times/Prentice Hall.

Tumi, S.A.H., Omran, A., & Pakir, A.H.K. (2009). Causes of delay in construction industry in libya. Paper presented at the The International Conference on Administration and Business, Bucharest.

Van de Ven, A. H. (1986). Central problems in the management of innovation. Management Science, 32(5), 590–607.

Van Der Weijde, G, 2008. Front end loading in the oil and gas industry, towards a fit front-end development phase, Delft University of Technology.

Van Thuyet, Nguyen, Stephen O. Ogunlana, and Prasanta Kumar Dey. "Risk management in oil and gas construction projects in Vietnam." International journal of energy sector management 1.2 (2007): 175-194.

Van Wyk, B. 2012. “Research design and methods Part 1,” University of Western Cape. Retrieved 09 August, 2014, from https://www.uwc.ac.za/Students/Postgraduate/Documents/Research_and_Design_I.pdf.

Verworn, B. and C. Herstatt (2002). The innovation process: an introduction to process models. Hamburg, Technische Universität Hamburg.

W. Jung, G. Ballard, Y. Kim, S. Han, Understanding of Target Value Design for Integrated Project Delivery with the Context of Game Theory. Construction Research Congress 2012: pp. 556-563.

Walewski, J. Gibson, G., Jasper, J. (2001). “Project Delivery Methods and Contracting Approaches Available for Implementation by the Texas Department of Transportation”, Texas Department of Transportation, Austin, Texas, 116 pages.

Walker, D and Hampson, K, (Eds) (2003) Procurement strategies: a relationship-based approach. London: Blackwell.

Walker, D. and Johannes, D. (2003). “Construction industry joint venture behavior in Hong Kong—designed for collaborative results?” International Journal of Project Management. Volume 21, Issue 1, 39–49.

Walker, D.H.T. (1995). An investigation into construction time performance. Construction Management and Economics, 13.

Walkup, G. W., & Ligon, J. R. (2006). The good, the bad, and the ugly of stage-gate project management process in the oil and gas industry. Paper presented at the 2006 SPE Annual Technical Conference and Exhibition.

Wamelink, J.W.F., Koolwijk, J.S.J., and Doorn, A.J. van (2012) Integrated project delivery: The designer as integrator .MCRP Conference Proceedings, Montreal, Canada.

Warfield J.W., Developing interconnected matrices in structural modelling, IEEE Transactions on Systems Men and Cybernetics, 4(1), 51-81 (1974).

Watson R., Interpretive Structural Modeling- A useful tool for worth assessment? Technological Forecasting and Social Change, 11, 165-185 (1978).

WEDAWATTA, G., INGIRIGE, B. & AMARATUNGA, D. Case study as a research strategy: Investigating extreme weather resilience of construction SMEs in the UK.

In: PERERA, S. & UDEJA, C., eds. ARCOM Doctoral

Workshop, International Conference on Disaster Resilience 2011 Kandalama,

Sri Lanka.

Wedawatta, Ingirige, & Amaratunga. (2011). Building up resilience of construction sector smes and their supply chains to extreme weather events. International Journal of Strategic Property Management, 14, 362-375.

Westney Consulting Group, 2008; Are Stages and Gates Destroying Predictability. http://www.westney.com/wp-content/uploads/2014/05/Are-Stages-and-Gates-Destroying-Predictability.pdf.

Westney, R. "Why projects overrun, and what to do about it." Houston, TX: Westney Consulting Group (2008).

William Paolillo, Branka V. Olson & Edward Straub (2016). “People Centered Innovation: Enabling Lean Integrated Project Delivery and Disrupting the Construction Industry for a More Sustainable Future”. Journal of Construction Engineering.

Wiss, R. A., Roberts, R. T., & Phraner, S. D. (2000). Beyond design-build-operate-maintain: New partnership approach toward fixed guideway transit

projects. Transportation Record Board, 1704, 13-18.

Wittig, Richard. Mega project development: optimising current practices and strategies. In: Conference, University of Wollongong, the Australasian Institute of Mining and Metallurgy, 392-398, 2013.

Yang, J.-B., Yang, C.-C., & Kao, C.-K. (2010). Evaluating schedule delay causes for private participating public construction works under the build-

operate-transfer model. International Journal of Project Management, 28(6),

569-579. doi: 10.1016/j.ijproman.2009.10.005.

Yerramreddy, Varun Aasish. Schedule Quality: Delay Analysis Perspective. Diss. TU Delft, Delft University of Technology, 2014.

Yeung, J., Cahn, A. and Chan, D. (2007). “The definition of alliancing in construction as a Wittgenstein family-resemblance concept.” International Journal of Project Management, Volume 25, Issue 3, 219–231.

Yin, R. K. (2009). Case study research: Design and methods (4 ed.). Los Angeles, CA: Sage.

Yin, R.K. 1989, Case Study Research Design and Methods, Sage, Newbury Park.

Zadeh, Mahsa Taghi, et al. "Factors Influencing Design Changes in Oil and Gas Projects." International Journal of Construction Engineering and Management 3.4 (2014): 117-133.

Zaneldin, E.K. (2006). Construction claims in united arab emirates: Types,

causes, and frequency. International Journal of Project Management, 24(5), 453-459. doi: 10.1016/j.ijproman.2006.02.006.

Appendix

1. **Ethical Application**

   1a. Ethical Approval form for Post Graduate Researchers

   1b. Ethical Attachments

2. **Interview**

3. **Data Analysis Sample**

   3a. Data Analysis Sample

   3b. Data Analysis Sample