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MASTER'S THESIS

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Writer: **Pavan Kumar Akella**	………………………………………… (Writer's signature)
Faculty supervisor: **Professor. Jayantha.P. Liyanage, Ph.D (UiS)** External supervisor(s): **Mr. Nils Erik Olsen and Mr. Eivind Eliassen**	
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ABSTRACT

Over the years, the faculty of Project management contributed excellent methodologies through a set of constituted guidelines that are applicable for smooth execution of projects in every industry. They are broadly based on initiating, planning, organizing, executing, and monitoring & controlling the process groups as a single entity. The implementation of project management methodologies is carried out through project management knowledge in specialized areas such as integration, scope, time, cost, quality, human resource, communications and risk. Projects are governed by factors that have major influence in directing the success or failures. Broadly cost, time & quality have been identified as key important success factors for projects. However, the factors are also governed by the complexity of projects and risk involved in project execution.

Over the decades the EPC contractors are trying to find solutions to cope up to the complexities colligated with significant risks in project execution. Extensive research is done by every contractor with an objective to integrate schedule and time management functions in an EPC project. Many scholars and researchers used different methodologies such as utility theory, scheduling milestones, cost milestones, performance index, cost accounting etc.

However, the focus has been primarily on the construction phase of the project and most often ignores the fact that success delivery of a project is a synchronous and integrated effort of all the disciplines involved in project execution.

This research is carried out to identify the critical success factors in EPC projects and establish the essential factors requisite for efficient execution. In a quest to define a framework that essentially facilitates identifying the critical success factors and their key influencing factors, a systematic investigation of established facts were used. The journey in search of knowledge through previously established researches and scholarly work culminated into the design and development of a framework methodology congenial to the current research environment. Collaboration with the research unit specialist groups and individuals helped to develop a survey questionnaire. The required data was acquired from selected participants of the EPC contractor organization that is specialized in offering EPC services in the oil & gas industry. The data was collected based on convenience statistical sampling technique. Acquired data was analyzed through univariate, bivariate, multivariate statistical techniques and identified the critical factors that require attention of the management of the organization under research. The findings indicated concurrence of established project success factors i.e. scope, time and cost with critical success factors identified and defined in the research. The results of analysis identified factors that are significantly affecting the efficiency of multidiscipline integration and co-ordination.

The research established that an integrated control system is necessary to the management as a tool that investigates and provides answers from the project stakeholders. Such a system provides the reflection of the factors that are directly or indirectly impacting the cost, schedule and quality constraints of a project.

Research Faculty Supervisor: Professor. Jayantha.P. Liyanage, Ph.D,
Professor & Chair, Centre for Industrial Asset Management (CIAM),
Faculty of Science & Technology, University of Stavanger

Research External Supervisors: Mr. Nils Erik Olsen and Mr. Eivind Eliassen

Researcher and Author: Mr. Pavan Kumar Akella
M.Sc Student, Faculty of Science & Technology,
University of Stavanger

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Dedicated to my father Shri. Akella Krishna Murthy, whom I try to emulate

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1 Introduction

1.1 Background

For any owner or client involved in an oil and gas business, the objective is to extract the maximum economic potential of his product. Experience has shown that this has been a challenge especially in large and complex projects. An EPC contract has been and is being used as a solution by the oil and gas companies to make the projects more efficient. EPC contracts follow the traditional bidding philosophies and alliance strategies in the form of risk and compensation. The alliance is initiated with an objective to share and promote the owner's terms, agreements and objectives among the project participants. However, with an objective to maximize the net present value of investments through increased production of oil and gas, the owner's lately shifted from long term projects to short-term alliance fast track projects. Developments in technology, degradation of equipments and systems due to wear and tear, increased health and safety standards, satellite technology and a need to maintain production levels are some of the reasons that justify the trend.

On the flip side, for an EPC contractor, the alliance with the oil and gas company owner through an EPC contract comes with an inherent challenge to mobilize, streamline and coordinate timely completion of the scope. The challenge to execute the contract successfully requires the management of association between the Engineering, Procurement and Construction Disciplines. Over the decades, the EPC contractors have been working with work processes and procedures to cater to the competency requirements of the market. Such a requirement is primarily governed by significant decrease in project execution life cycle along with changes in technology. In addition to the aforesaid, with a significant increase in client/customer power, it has become necessary for the contractor to map the dependencies between the main phases of the project (planning, design, procurement, construction) and within the project (across disciplines mechanical, process, piping structural etc). The solution to manage the project discipline dependencies is to resolve the gaps in communication, division of responsibilities, and information transfer through a process of integration and coordination.

The result is a comprehensive EPC management in the form of a concurrent engineering management system, dedicating its efforts to investigate, visualize and optimize the work processes with a need to create an environment for integrated activities and quality improvement.

1.2 Problem Description

Competition in the Oil and Gas industry has been fierce over the past decade with demanding clients focusing strictly on the quality, schedule and cost. In a traditional sequential contract model, the owner plays the important role of a project manager and exerts significant influence and intervention in the project execution activities. It was not too long before the owners of the oil and gas companies have realized that the traditional sequential engineering, procurement and construction process to execute a project consumes more time, requires more costs and produces inferior quality of the final deliverable. The introduction of EPC contract model has seen the owner taking the back seat with limited responsibilities by transferring the risks associated with a project to the EPC contractor. Instead of directly participating in the project execution activities, the owner limited his responsibilities to defining the scope of the project, clarifying technical queries, handling variation orders and defining technical standards.

The responsibility of the EPC contractor starts upon the award or signing of a contract and thereafter is entitled to own the entire risk associated in project execution from the owner. For an EPC contractor, in order to survive in the fast-changing and highly competitive market, the contractor organization must be agile and respond quickly to the requirements of changing market. Shorter development cycle times, short span of project execution activities and schedule predictability are the three basic indicators of performance that lead to a successful project delivery. In recent years, with the use of EPC contract model, the faculty of concurrent engineering management has found its extreme importance and influence in project development and execution. Majority of the challenges that arise in executing a complex EPC project cannot be attributed simply to the technical complexities. The complexity is also associated with the management of interactions between the different engineering and project disciplines that impose a challenge on the project outcomes.

Concurrent engineering management is a philosophy adapted by the EPC contractors to simultaneously involve all the participating stakeholders of project execution for a common objective of the project. But the essence of concurrent engineering management system is appreciated and realized only if the organization is capable of managing the complexities involved in the smooth transition of the sequential project execution activities to a well-organized and synchronized project execution activities.

Traditionally the project triangle represents the major constraints of a project. To deliver the scope on time (schedule), within the budget (cost) and with the right quality is considered a '*Success'*. In order to find a solution for handling the project constraints most of the EPC contractors, especially executing maintenance and modification contracts in Norwegian Continental Shelf, have an extensive and cumbersome quality management system. Such a system consists of well written procedures with many projects customized versions based on the experience and knowledge gained over a period of contracts execution. The initiation of such a system is to help the disciplines to follow procedures and to advocate towards the application of multidiscipline and concurrent engineering integrative approaches for solving the pressing challenges of technical and managerial complexities.

Although there is a growing interest in multidiscipline and concurrent engineering integrative concepts, there has been a lack of common understanding as to what these concepts mean and how they execute in the real project environment.

The challenge to the EPC contractor is to periodically ensure and gauge whether the system is efficient enough, whether the system accommodated the changes (socio-technically), whether the system is implemented and whether the system is being functional. It therefore becomes necessary to the management to analyze the multidiscipline integrative concepts and check if the expected outcomes of integration is specified, implemented and followed.

The objective of such a system is to manage the project activities in such a way that the project scope is delivered on time (schedule goal), within the budget (cost goal) and to the right specification/quality (quality goal). Most of the contractors have a system or a model or a basis or a theory or a methodology synonymous to the EPC concurrent engineering management system in the form of multi discipline routines and procedures but the question to be asked is '*Are They Efficient enough?'*

1.3 Objectives

The primary objective is derived from the aforementioned problem definition. The objective of this research is to propose a set of definitions, not as a fixed understanding of the integrative concepts, but as a means of communication that will help specialized project disciplines to share experiences and communicate on integrative concepts and methods.

The efficiency of integration of all the participating disciplines is studied with respect to their individual work processes and their mapping with other disciplines. The measurement results are intentive to provide the management as a justification to make decisions in areas that require focus and attention. The efficiency of integration of all the participating disciplines is studied with respect to their individual work processes and their mapping with other disciplines. In addition the aim is to exploit the production of knowledge as a bi-product and give an opportunity to the management and each project discipline to have a reflection on their deliverables and responsibilities necessary for the success of the project and therefore the EPC contractor organization

1.3.1 Sub Objectives

To enhance the multidiscipline coordination's activities the underlying 'Types' (issues associated with the organization and managerial decisions which include recurrent error traps in the work place and the organizational processes that give rise to them) and 'Tokens' (issues resulting from the man-machine interface and work environment, social facts and information processing factors) have to be focused on to create an efficient EPC concurrent engineering management system. In doing so some of the socio-technical factors were considered important and hence have been adapted in this research. The ultimate goal for any EPC contractor is not only to tick off the project as 'Success' with respect to the three constraints of the project execution but also to ensure that the project has a prefix 'Efficient'. This is to be envisaged by ensuring that the respective stakeholders of each discipline and the discipline itself as an entity understands the ultimate goal of executing the project within the schedule, under the budget without a compromise on quality requirement from the standards or the client.

The terms such as integration, multidiscipline (interdiscipline and intradiscipline), coordination, participation, and collaboration are studied across various disciplines and checked to see if the cooperation between the disciplines is crossing their respective boundaries to meet the common goal. The sub objectives of this research are:

- Study the EPC compensation models used in the industry
- Study the pros and cons of the EPC compensation models with respect to the owner and the contractor
- Study the different incentive schemes applicable in the oil and gas industry
- Understand and define the concepts of multidiscipline integration in an EPC project execution environment
- Understand and define the multidiscipline coordination mechanisms used in an EPC project execution environment
- Identify and map the components of multidiscipline integration and coordination to the components of project execution
- Understand the importance of measuring multidiscipline integration and coordination
- Deduce or develop a mechanism or a methodology to measure the efficiency of multidiscipline integration and coordination
- Identify and describe the characteristics of the critical factors that determine the EPC project performance
- Identify and define the factors that can influence the EPC project performance
- Analyse the impact of factors on each other and their level of escalation on EPC project performance
- Identify and analyze the dependencies that are influencing the project performance

1.4 Research Summary

The background, problem definition and the eventual objectives and sub-objectives of this research are presented in *chapter 1*. The chapter also presents a summary of this report along with the limitations and assumptions of this research. The EPC contractor researched is one of the leading suppliers of EPC services in the oil and gas industry on the Norwegian continental shelf and the profile of the research unit is described in *chapter 2*. *Chapter 3* of the research defines EPC contract and the type of compensation models used in the oil and gas industry. In addition the chapter provides an overview of the incentive schemes that are generally negotiated between the owner and the EPC contractor. *Chapter 4*, *Chapter 5* and *Chapter 6* define the terms multidiscipline, integration and coordination respectively in an EPC environment and their relationship is summarized in *chapter 7*. The description and justification for the need to measure multidiscipline integration and coordination in an EPC contractor organization is presented in *chapter 7*. In an effort to find a performance measurement model suitable to measure multidiscipline integration and coordination in an EPC contractor organization, the researcher in *chapter 8* examines four performance measurement models (Measurement Linkage Model, Integrated Performance Measurement System, Balanced Scorecard and Strategic Measurement Model). After investigating the strengths and weaknesses of the four measurement models, the researcher is motivated to design a model congenial for the current research and is described in *chapter 9*.

The research defined the significance and importance of seven critical success factors that can exert their influence on the competency and objectives of the research unit. Based on the researcher's construct of the measurement model developed for this study, the critical success factors studied in this research are *'Project Performance', 'Front End Planning/Start-up Plan', 'Project Execution', 'Best Practices', 'Information and Communications Technology', 'Project Organization', 'Knowledge Management' and 'Benchmarking'*. The researcher designed a survey questionnaire for gathering the baseline data to determine the performance of the projects executed or being executed at the research unit using eleven dependent variables. The fourteen dependent variables measured are cost/schedule goals achieved based on policies governing budget/schedule estimates, level of customer satisfaction with respect to meeting the quality, schedule and cost goals, level of engineering performance with respect to productivity, quality adherence and timely completion of the job, level of procurement performance with respect to productivity, quality adherence and timely completion of the job, level of construction performance with respect to productivity, quality adherence and timely completion of the job, amount of construction rework due to inferior engineering quality, level of escalation contributed to project cost/schedule due to inferior engineering quality, level of escalation contributed to project cost/schedule due to inferior procurement quality, level of escalation contributed to project cost/schedule due to inferior construction quality, construction rework due to a team or team member and amount of rework as a result of incorrect or inferior quality of information from dependents. Fifty five key influencing factors taking the role of independent or input variables are included in the survey questionnaire to predict their measured effect on the project performance and at the same time evaluate the efficiency of critical success factors *(see chapter 9).*

The target population is grouped into three main categories namely *'Team Member' (TM)*, *'Team Leader' (TL)* and *'Project Manager' (PM)*. Three survey questionnaires are designed using one-to-one and one-to-many brainstorming interviews and meetings with the specialist individuals of the research unit. The questionnaire is used as an instrument to gather the responses from the employees of the research unit. The questionnaires and the covering letter are included in the *Appendix* section of this research report. The research sample population, research questionnaire, sample size and measurement scaling used in this study are discussed in *chapter 10*.

The profile of the research sample population and project profile of the research unit is presented in *chapter 11*. The questionnaire is designed for planned missing data and hence the researcher has conditionally not defined certain questions to specific groups of the research population based on their current roles and responsibilities held in the project organization. The research used the statistical multiple imputation technique for handling the planned missing data using SPSS v20 application. The descriptive and univariate statistics of the missing values is presented in *chapter 13*.

Out of the three available types of descriptive univariate statistics, the researcher used the measures of central tendency and measures of variability to present the data gathered through the responses. Cronbach-Alpha coefficient is used to check the reliability of the responses. For variables under each critical success factor observed, the statistical univariate analysis results such as central tendency and dispersion of the research variables are presented *chapter 12* (for observed) and *chapter 14 (for imputed)* using mean, median, range, variance and standard deviation.

Factor analysis and multiple regression analysis are the two multivariate analysis techniques used in this research. Factor analysis is used to as a statistical dimension reduction technique to analyze the interdependence among variables and the empirical results are presented in *chapter 15.* Multiple regression analysis along with hypothesis testing is used to check if the dependence of one variable can be explained for its effect by other independent variables. The empirical results and discussion of multivariate analysis are presented in *chapter 16*.

Statistical Bivariate analysis using Pearson's correlation coefficient *'r'* is used by the researcher to infer the possible relationship among the research variables (between dependent variables, between independent variables and between independent and dependent variables) identified and observed and the empirical results are presented *chapter 17*. *Chapter 18* presents the conclusion and implication of this research.

1.5 Research Limitations and Assumptions

- The research is limited to one of the leading suppliers of EPC services in the oil and gas industry on the Norwegian Continental Shelf (NCS) and does not include the neither the sub-contractors of the EPC contractor's organization nor the owner/client
- The research included the responses gathered through the research instrument (questionnaire) from five engineering disciplines namely mechanical, electrical and instrumentation, Piping and layout, process and structural and assumed representing the horizontal component of project execution
- The respondents have been asked to answer the research questionnaire grounding on the projects that are ongoing and the projects that have been executed at the EPC contractor's organization
- The research population includes only the staff employees of the EPC contractor's organization and excludes the consultants and partnering company employees who are a part of the ongoing projects
- A key assumption made in this study is that the project manager could serve as a representative for the construction and procurement personnel. Hence, the project manager acted as a proxy for responding to the questions relevant to the construction and procurement group personnel
- Information and Communications technology group personnel are a not a part of the survey population
- Due to large research population size, statistical sampling technique has been used to reach the objective of this research
- The research used planned missing data questionnaire as a survey instrument and thereafter uses statistical multiple imputation technique to populate the missing data
- The complexity of the projects being executed is not a factor that has been taken into consideration while analysing the responses
- In analysing the responses gathered in this study, client's participation and his influence in project execution has not been considered
- The researcher could not find any empirical investigation of the research topic within the contractor's organization or within the local market industry. Hence the findings and outcomes of this research are limited to the EPC contractor organization under study but can conditionally extend to other EPC contractors.
- The research assumed that the gathered responses will be able to provide true information about the organization and project performance through the survey questionnaire

2 Research Environment

2.1 Research Unit

The EPC contractor researched is one of the leading suppliers of EPC services in the oil and gas industry on the Norwegian continental shelf, with approximately 600 employees. The contractor specializes within a broad market with missions varying from small and simple to large and complex. The contractor's diverse business specialization includes design and construction of modules, environment technological projects, modification / repair of rigs, ships and platforms, subsea, land and construction of structures and pipes. The value chain includes everything from concept development, design, fabrication and installation for testing. The contractor organization is organized into five Engineering disciplines under the engineering division along with procurement, construction and project management disciplines.

2.1.1 Engineering Division

The Engineering division is responsible for the design and detailed engineering services and is organized into five engineering disciplines.

2.1.1.1 Structural and Outfitting

The department covers all engineering phases within structural, marine, architect, surface protection and weight control. In addition, the department is also responsible for the engineering work related to all building methods and sequences, handling, transport and lifting of small and large structures and modules onshore, inshore and offshore.

2.1.1.2 Piping and Layout

The piping and layout department is responsible for the overall layout solutions within new build, subsea and maintenance & modification contracts. The department is responsible for design and shop engineering of all sorts of pipe systems and arrangements ranging from design of single spools to design of complex process and utilities piping arrangements including stress analysis of piping systems and pipe support design.

2.1.1.3 Process, Mechanical and Technical Safety

The department covers the Process, Mechanical and Technical Safety disciplines within the Engineering and Procurement Division. The department is responsible for all aspects of the projects, such as studies, feed engineering, detail engineering, fabrication, construction, testing, commissioning and follow-up of projects.

2.1.1.4 EIT and Completion

The department covers the Electrical, Automation and Telecommunication disciplines and is also responsible for the completion phase of all the projects. The department is responsible for design and specification of all types of systems ranging from simple electrical systems to specification and procurement of complex process and control systems.

2.1.1.5 Information Technology and Systems

Information Technology and Systems department has the overall responsibility for all information systems, information technology and document control.

2.1.2 Procurement Division

The procurement department is overall responsible for the Order placement and Order execution process for all bulk and equipment purchases, indirect materials and procurement of other services. The department is also responsible for the maintenance and co-ordination of existing and new long term frame agreements and vendor relations.

2.1.3 Construction Division

The construction department is the core group of any EPC contractor and holds the responsibilities of the pre-fabrication, testing, fabrication quality, construction methods, construction safety, fabrication, installation at owner's site and commissioning.

2.1.4 Project Management Division

In addition to the above, the contractor has a pool of project, engineering and completion managers with long experience from technology development activities, concept studies, FEED's, execution of various EPCI and FC contracts.

2.2 Research Population

The research population includes all the permanent staff employees of the EPC contractor from the project management, engineering, procurement, and construction divisions. The project is organized in the form of categorized teams according to their specialization, autonomy and contribution to the project. The scope of the project specializations is split among the teams through the team leaders according to their functions and responsibilities. According to the needs of the project the teams can be further split into sub-teams. The major divisions of a typical project are represented using a project organization chart as shown in *figure 2.1*.

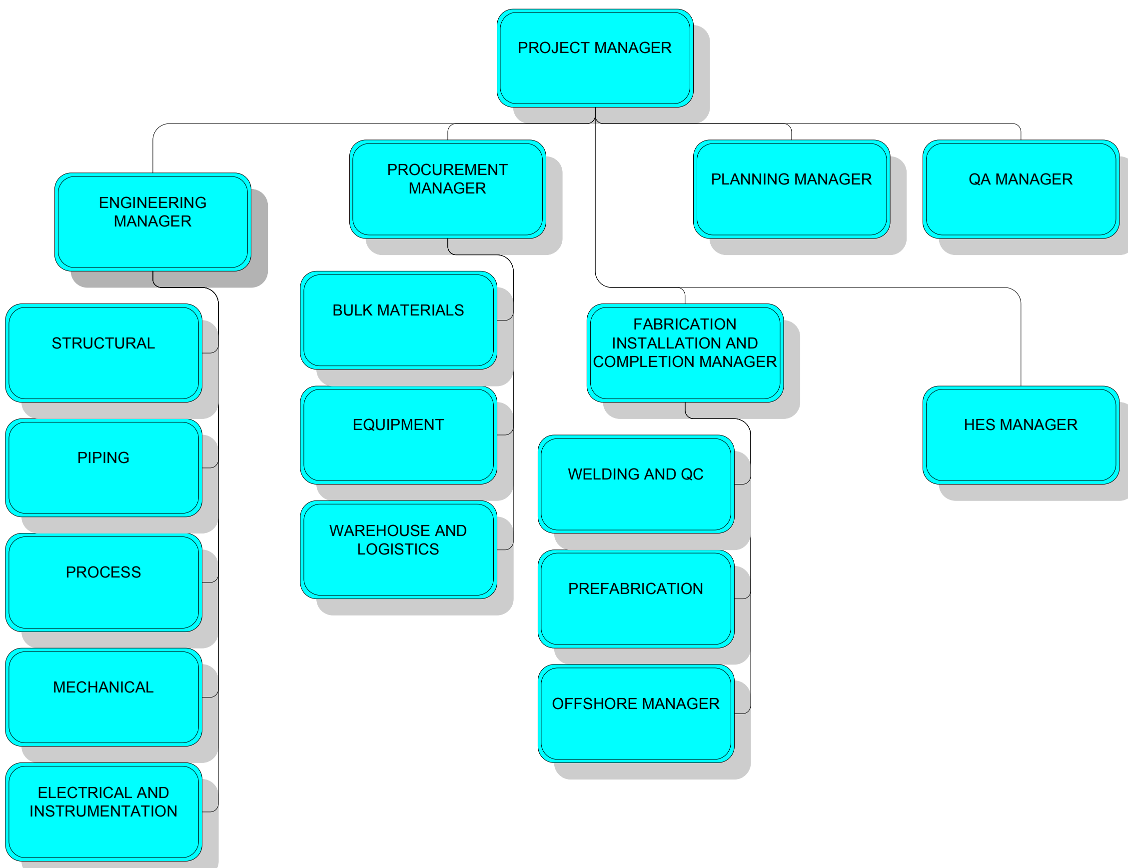


Figure 2.1: Typical Project Execution Organisation Chart

3 Engineering-Procurement-Construction (E-P-C) Contract

3.1 Introduction

Over the years, the oil and gas industry has utilized various contract models negotiated between the contractor and the owner of a facility. However, in an effort to control and regulate the deliveries, lately the owners are more trended towards the Engineering-Procurement-Construction (E-P-C) contract format. Ever since the emergence of the contract model in Japan in 1980, the E-P-C contract model has been favoured by many owners and has gradually found its reach and influence in the international engineering contracts and awards (Chen 2009, cited in Liu, Han and Han 2010). The possibility to determine and quantify the key constraints of a project such as the amount to be invested and the possible cycle time are the main factors that contributed to the widespread adaptation of the model. Unlike in a traditional contractual model, where the contractor comes into the project execution only during the construction phase, the E-P-C contract makes the contractor responsible for all the project execution activities such as detailed designing, procurement, and construction. The change has been primarily governed by factors such as

- Shortening of the project life cycle time
- Inconsistencies between design and construction resulting in rework
- Higher risk at the owner's end

The emergence of E-P-C contract has seen a well organized, communicated, optimized and integrated set of project execution activities in the engineering, procurement and construction disciplines leading to better quality, shortened duration, shared risk, optimized design, optimized purchasing and improve constructability (Wei 2009, cited in Hongyong, Neng and Xia 2010).

With the absence of a formal and concise definition, the researcher constructed the definition for E-P-C contract as: 'An agreement that contemplates a single contractor to be responsible for the entire project scope as agreed between the contactor and the owner, by construction and testing through designing the installation and procuring all the necessary materials and equipment. The contractor carries the project risk for budget along with schedule in return for a agreed compensation model using contractors own labour or by sub contracting a part of scope to another firm. Depending upon the owner's requirements, a separate arrangement/agreement, even though not under the linguistic terms of the EPC contract can be negotiated which allows the 'contractor' designated as a commercial operator of the facility'.

Owing to the advantages of involving the contractor, the E-P-C contract has been extended to other alternatives such as E-P-C-I (engineering, procurement, construction and Installation) and E-P-C-I-C (engineering, procurement, construction, Installation and Commissioning). The researchers construct illustrating the definition of E-P-C contract is shown pictorially in *figure 3.1*.

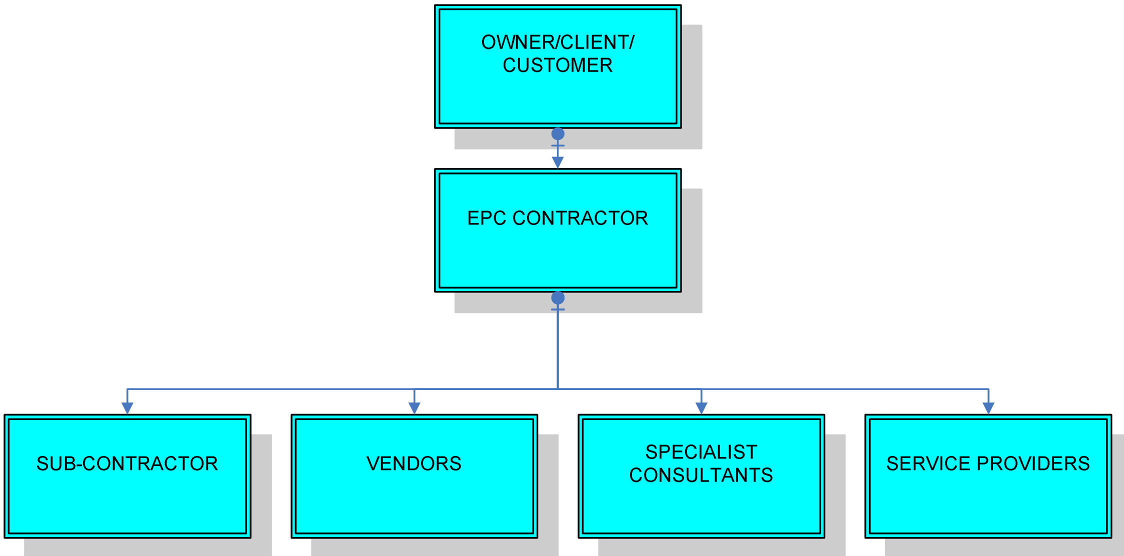


Figure 3.1: E-P-C Contract Definition

3.2 Functions of an E-P-C contract

The functions of an E-P-C contract vary depending upon the economy, technique, resources, amount of preparatory work, size and complexity of the project etc. However, an agreement negotiated between the client and the contractor enwraps sometimes a few or most often all the typical and key functions as shown in *table 3.1*.

Discipline	Function
Engineering	⌖ Design scope ⌖ Design basis and technical standards ⌖ Design document inspection and approval ⌖ Design responsibility ⌖ Compiling and submission of the completed documents and operation and maintenance manual ⌖ Design control and design outcome document
Procurement	⌖ General responsibility for procurement ⌖ Monitoring and Scheduling procurement process ⌖ The assistance of the owners ⌖ Employer Supplied Items
Construction	⌖ Regulations on construction ⌖ Regulations on construction quality ⌖ Regulations on construction schedule in EPC contract. ⌖ Regulations and provisions relating to HSE
Contractor	⌖ Risk Sharing ⌖ Protect owner upon contractor's failure from delivery

	⌖ Conditions for Performance incentives for Contractor ⌖ Payment plan or agreement from Company to Contractor

Table 3.1: Function of an E-P-C Contract

3.3 EPC Contract Structure

Several approaches are used by a client or customer to structure the contract that is bankable and ensures the establishment of a single point accountability/responsibility. Such an approach is ruled by the client's risk averse characteristics following the significant risk and unfortunate incidents involved in recent history of oil and gas industry. The contents or the structure of a typical EPC contract are summarized in *table 3.2*.

EPC Contract Contents
Exhibit A - Scope of Work
Exhibit B - Schedule and Milestones
Exhibit C - Compensation and Payment
Exhibit D - Health, Safety and Environment Requirements
Appendix D1 - HSE Policy
Appendix D2 - General HSE Requirements
Appendix D3 - Additional Offshore HSE Requirements
Appendix D4 - Offshore Working Time Standards, Duties and Guidelines
Appendix D5 - Substance Misuse Policy
Exhibit E - Specifications, Drawings and Technical Specifications
Exhibit F - Basis of Design
Exhibit G - Company Provided Items
Exhibit H - Project Control and Administration
Exhibit I - Approved Subcontractors
Exhibit J - Procurement and Material Control
Exhibit K - Document Management and IT
Exhibit L - Key Personnel
Exhibit M - Company Code of Business Ethics and Conduct
Exhibit N - Sample Variation Order Form
Exhibit O - Information Security Access Agreement

Table 3.2: EPC Contract Structure

(Source : ConocoPhillips Skandinavia AS Greater Ekofisk Area Development)

With low risk tolerance levels, the contract structure is determined by factors such as legalities, regulations, compensation methodology, size of the project, type of project, environmental requirements, risk sharing between the contractor and owner, lifetime of project execution, division of responsibilities, interfaces, performance security, variations, insurance etc.

3.4 EPC Contract Advantages and Disadvantages

The governing objective for the implementation of an EPC contract in today's oil and gas industry is to make the projects more time and cost efficient in order to maximize the Net Present Value (NPV) of the investments. Despite the complexities involved in the EPC contract model, it has been adapted by the owner's and the EPC contractors in a format that maintains a balance of interest between both the parties. Some of the advantages and disadvantages to both the parties are listed below

3.4.1 Contractor's Advantages

Equipment Supplies along with On-site construction is solely owned by contractor and hence the owner is not a part of the negotiations with the vendors or subcontractors

- Any cost savings in equipment or services are into the contractor's account unless it is not agreed upon in the contract agreement
- Supplier selection is solely the responsibility of the contractor with no interference from the owner
- Process warranties are negotiated solely between the contractor and the supplier
- Ownership of the process with an opportunity for optimization enhances the likelihood of earning more benefits than negotiated

3.4.2 Owner's Advantages

- Single point of contact for communication and coordination
- Reduced Project duration
- Reduced administration costs
- Minimal staff is required to monitor the project progress and quality
- Legal costs are reduced as the contractor is responsible for individual contracts with each of the suppliers or vendors or sub contractors
- Owner can concentrate on his core business interests
- Long lead items are purchased by the owner even before the contract is awarded
- Demarcation of obligations and responsibilities between the contractor and the owner

3.4.3 Contractor's Disadvantages

- The contractor bears the cost overruns or schedule overruns risks.
- The day to day expenses are borne by the contractor within the scope of supply
- Higher legal costs as the contractor is responsible for all the individual contracts with each of the suppliers or vendors or sub contractors
- All the complex dependencies are handled by the contractor

3.4.4 Owner's Disadvantages

- Owner misses an opportunity to shop around for multiple options from independent contractors or suppliers due to contractor's sole contact with the owner
- Large Contractors makes the market segment vulnerable to capacity problems and insufficient competition
- High risk adverse behaviour, which results in high risk premiums being included in tender prices

- Hedging against performance, possible cost overrun and potential loss can lead to high contractual costs
- High contract costs as the contract bears most of the risk (Project Management Institute, 1996) (McNair, Delkousis and Marsh, 2004).

3.5 EPC Compensation Models

One of the challenges of an EPC contract is to decide upon the type of compensation method or financial terms agreeable to both the owner as well as the contractor. Attributing to the differences in the nature of work among the three major departments (Engineering, Procurement and Construction), four different compensation models are used in today's market in order to satisfy and maintain the interest of both the owner and the contractor. According to Construction Industry Institute (1986), the choice of the compensation model depends on the following factors.

- The accuracy, definition and extent of work to be executed
- The risk appetite of the owner and the contractor
- The extent of owner availability, participation and influence on the execution of the project scope
- Short-term alliance and reduced project execution life time
- Conditions and trends in the market place

3.5.1 Cost Reimbursable or Cost Plus or Target Sum Model

The Cost Reimbursable pricing model is characterized by target cost agreed upon by the owner and the contractor. The compensation model allows any adjustments to the financials terms with respect to project execution costs. The target cost comprises of two components:

- Cost of contingency, cost (direct or indirect) and profit to produce the deliverable as per the contractual terms
- Fixed or variable fee

If the contractor executes the project scope as agreed upon and within the target cost, the contractor is compensated with a fixed/variable fee in addition to the direct and indirect cost expended on the project. However, if the project consumes more than the target cost, only the direct and indirect costs are reimbursed to the contractor.

3.5.2 Unit rate or Unit Price Model

Unit rate method is characterized by the inaccuracy of determining the project activities. In other words the unit rate method is adapted when the project activities cannot be quantified. In this model, the contractor is paid on the basis of a preset price agreed with the owner for each unit of activity completed. In other words, the contractor is paid a fixed actual price in accordance to actual units of EPC services offered. As a result the owner has to consume the risk of increased variations in project activities or a quantity built but comes with an advantage of making changes to the volumes of work entailing more control.

3.5.3 Lump Sum Fixed Price Model

The fixed price compensation model consists of financial terms that require the contractor to *'establish a stipulated sum for the completion or execution of a defined quantity of work'* (Construction Industry Institute, 1986). The pricing method is based upon a specific cost agreed upon by the contractor and the owner when signing the contract. The contractor has to bear all the cost overruns if any and owing to the high risk involved, the contractor generally exaggerates the contract price. Even though, the contract comes with an advantage of well defined scope and ensures that the project is executed in the lowest possible price, the owner has to bear the risk of inferior quality and ignores the opportunity for adapting a new technology by the contractor.

3.5.4 Lump Sum Price/Reimbursable Model

The Lump Sum Turn Key pricing or simply referred to as Turn Key model finds its application if the scope, duration and nature of work can be defined accurately. In this model, the contractor is compensated with a fixed price as agreed upon with the owner to perform a defined scope. The scope will/may include engineering services, the procurement of materials and construction services as agreed. Any cost overruns whether direct or indirect has to be borne by the contractor (Galloway, 2009) (Agnitsch, Cooke and Solberg, 2001).

3.6 Selection of a Compensation Model

Construction Industry Institute (1986), points out the following characteristics governing compensation model or contracting strategy between the owner and the contractor.

- Risk allocation is primarily directed towards the contractor in fixed price contracts
- Risk allocation primarily directed towards the owner in cost reimbursable contracts
- More administrative time is required from the in cost reimbursable contracts
- Environment is less adversarial in cost plus contracts
- Documentation and scope definition effort is more critical in fixed price contracts
- Fixed price contracts provide less incentive for high quality work
- Cost plus contracts provide more flexibility to change in design or scope
- Cost reimbursable contracts minimize the schedule while fixed price contracts minimize costs

Figure 3.2 outlines how the elements of control exercise their impact for the various pricing models discussed in *section 3.5*

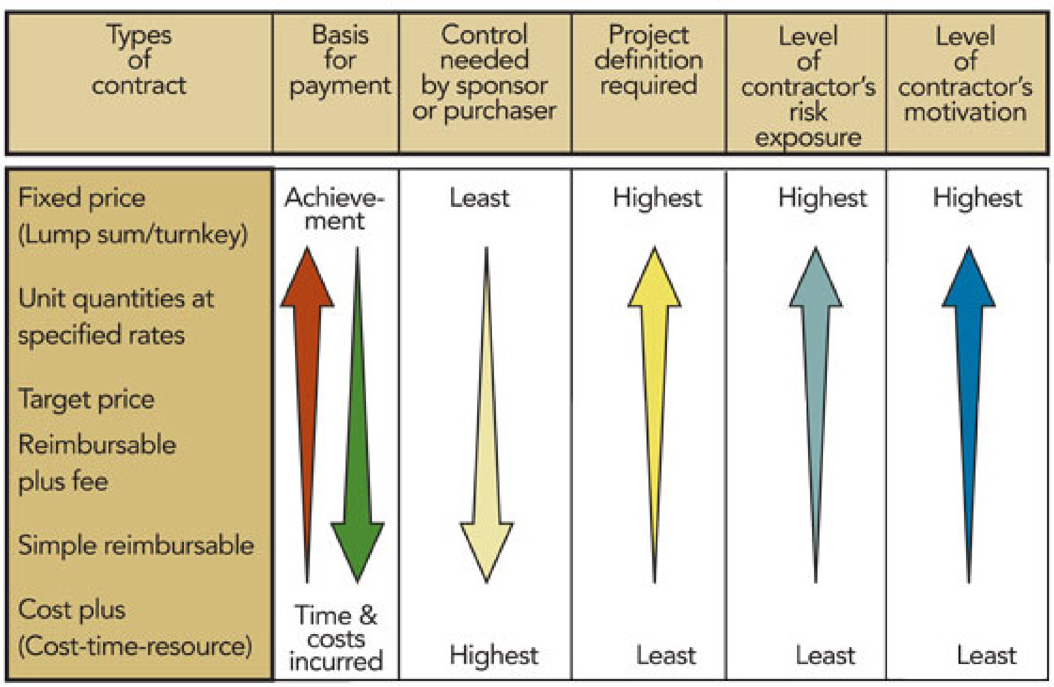


Figure 3.2: Level of Impact of Elements of Control on the Compensation/Pricing Models

(Source: http://www.ogfj.com/articles/2011/09/staffing-strategies-for-large-projects-must.html)

3.7 Compensation Model Alignment

Table 3.3 shows how the above pricing or compensation models defined in *section 3.5* are aligned to the three major components of Engineering, Procurement and Construction project. The format is based upon the learning experiences of both the contractor and the owner over a period of time with both parties aligning and adjusting to each other's commercial interest (Salvesen, 2011).

DISCIPLINE	SERVICE	COMPENSATION METHOD
Preliminaries	Project Management and Facilities	Lump Sum
	Project Office and IT infrastructure	Unit Price
	Miscellaneous Services to the Contractor	Cost Reimbursable
Engineering	Engineering Discipline Personnel	Hourly Rates
Procurement	Tagged Equipment and Materials procured under the frame agreements	Cost Reimbursable
	Procurement Discipline Personnel	Hourly Rates
	Bulk Materials	Unit Prices
Construction	Prefabrication Modules	Unit Prices
	Offshore Work	Unit Prices or Hourly Rates

Table 3.3: Compensation Model Alignment in an EPC Contract

(Source-Statoil procurement presentation, 2010)

3.8 Risk Distribution

Figure 3.3 represents the distribution of risk in the form of commercial exposure between the contractor and the owner for the governing departments mapped against the compensation models.

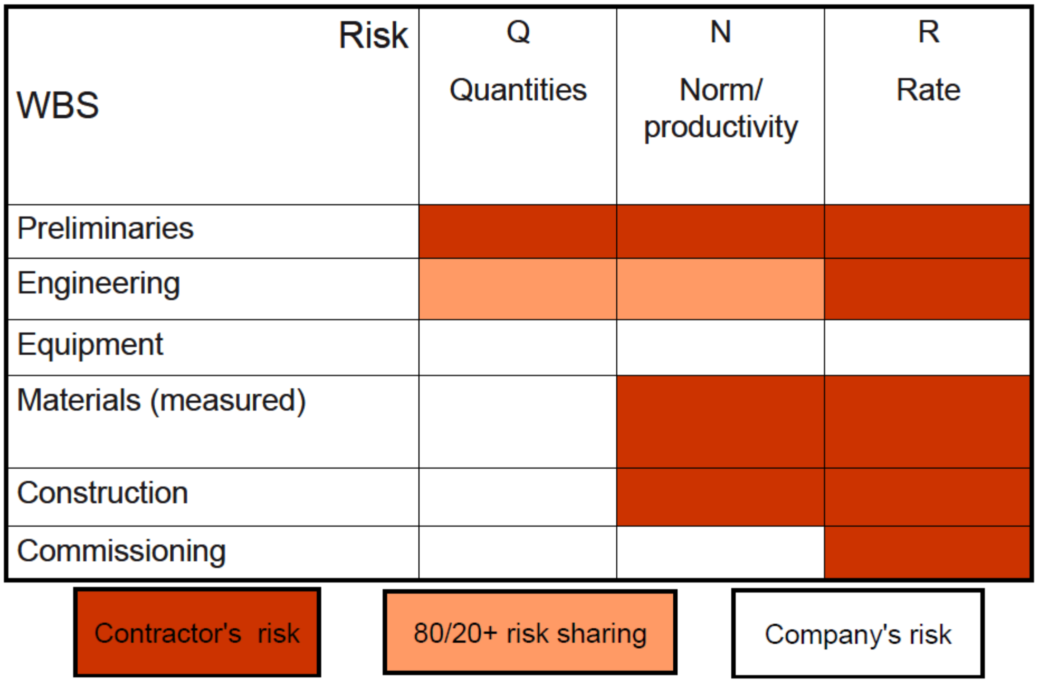


Figure 3.3: Distribution of commercial exposure Vs Compensation Models

(Source: Contractual Incentives in EPC Contracts – Salvesen, 2011)

3.9 Overview of Incentive Schemes to the Contractor

Apart from the compensation model agreed between the contractor and the owner, the owner may include additional component of payment subject to the contractor's compliance to the conditions (performance milestones) in the contract. The owner introduces the incentive schemes to

- Encourage the contractor for early completion of the project and thereby reduce cost
- Improve owner's return on investments
- Reduce defensive documentation
- Encourage contractor to focus on the quality of deliverables
- Encourage the project team to exceed the owner's business objectives
- Establish long term relationships
- Increase contractor control (Howard and Bell, 1998)

3.9.1 Bonus-Penalty Milestones or Incentive-Disincentive Milestones Scheme

The bonus and penalty milestones incentive scheme is used by the owner to reward or to penalise the contractor against milestones agreed or negotiated during the signing of the contract. The bonus milestones are generally offered by the owner when the project is completed ahead of schedule or when a performance benchmark in quality of project deliverables has been meet in accordance to the safety obligations of the owners. The incentive can be extended to the contractors in case of any innovations that lead to the project cost under runs or owner's advantage. On the contrary the penalty incentive is used by the owner to penalize the contractor for not obligating to the contractual obligations or performance milestones. The performance milestones are generally with respect to schedule or quality (Bubshait, 2003)

3.9.2 Engineering Target Hour's Incentive Scheme

The scheme finds its application in encouraging the contractor to use less number of hours than the target hours agreed upon during the signing of the contract. The target hours are an estimate as agreed upon with the owner and is recommended by the contractor based on his experience. The contractor receives an obligatory lump sum irrespective of the number of hours used in engineering and has an opportunity to bank all the unused target hours. However, if the contractor exceeds the target hours, the owner compensates the contractor at a reduced unit rate.

3.9.3 Weight Incentive

The essence of weight of the tangible deliverables on a project bears utmost importance especially in offshore platforms. Optimization in weight or use of weight control methods is the responsibility of the contractor. The optimization effort from the contractor translates into an advantage to the owner by allowing the owner to introduce new upgrades or technologies. The contract is incentivized weight wise to allow the contractor to try new and robust EPC solutions than compared to the traditional solutions. In this scheme the contractor is compensated in the form of a reward for each reduced tonnage of installation.

3.9.4 Quality Incentive

Quality, one of the key success factors of project execution activities, is roped into the incentive circle so that the owner can monitor and have a better control over the deliverable from the contractor. The scheme rewards the contractor upon meeting a predetermined quality benchmarks in engineering, procurement and construction. However, the performance indicators vary for each component of the three services offered in an EPC project and a few are summarized in *table 3.4.*

Department/Discipline	Performance benchmark
Engineering	⌖ Design revision/re-work ⌖ Independence from dependent disciplines ⌖ Design reviews ⌖ Change orders ⌖ IFC Drawings
Procurement	⌖ Quality and reliability of the purchased goods ⌖ Cost of goods ⌖ Maintenance cost of the purchased goods
Construction	⌖ Rework ⌖ Shutdown duration ⌖ Independence from dependent disciplines

Table 3.4: Performance Benchmark's for EPC Project Components

3.9.5 Project Control Incentive

The contract between the contractor and the owner is preliminarily based on estimates in terms of cost, scope, contingencies and schedule. The estimates are used as basis for budgeting, project planning, and schedule control with the actual expended during the process of project execution. To increase the contractor's involvement in monitoring the estimates and to enable him to anticipate the resources required during the execution cycle, the owner can introduce a reward for project control. In other words, this is a reward to the contractor for satisfying the obligations or meeting the key performance indicators decided upon in the contract. The schedule performance index and cost performance index allows the contractor to find the difference between the estimates and the actual, thereby unfolding an opportunity to enhance the intrinsic execution process of a project.

4 What is Multidiscipline in an EPC Environment?

4.1 Introduction

One of the advantages of an EPC contract to the owner is the simultaneous execution of Engineering, Procurement and Construction activities by the contractor to accomplish the common goal defined in the contract. *'Multi'* is a prefix added to the various disciplines involved in the project execution with and within the expertise of their domain. The disciplines involvement in the project is characterized by their participation in creating a tangible or non-tangible value generating information and at the same time act as participants to exchange information/knowledge to whom they owe the deliverable. The disciplines do not cross the virtual boundaries of well defined knowledge or expertise and focus on adhering to their part of project responsibilities.

4.2 Multidisciplinary Teamwork

Before understanding the definition of Multidisciplinary Teamwork, it is important to know definition of the term 'team'. Cohen and Bailey (1997, p.241), in their journal article of management '*What makes teams work: Group effectiveness research from the shop floor to the executive suite' defined team as 'A team is a collection of individuals who are interdependent in their task, who share responsibilities for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems (for example, business unit of the corporation), and who manage their relationship across boundaries'.*

Teams is the way the organizations/projects group logically in the name of structure to enhance output, improve quality, reduce cost and enable better decisions. There are many types of team in an organization like top management teams, cross functional teams, self managed/independent work execution teams.

Going by the term Multidisciplinary Teamwork, the definition can be derived as '*teams and members of different disciplines working towards a common goal by obliging to their responsibilities/tasks'* for the following reasons as provides by Handy (1981, pp.155-156):

- For the distribution of work: To bring together a set of skills, talents, responsibilities, and allocate to them their particular duties
- For the management and control of work: To allow work to be organized and controlled by appropriate individuals with responsibility for a certain range of work
- For problem-solving and decision-taking: To bring together a set of skills, talents and responsibilities so that the solution to any problem will have all available capacities applied to it.
- For information processing: To pass on decisions or information to those who need to know.
- For information and idea collection: To gather ideas, information or suggestions
- For testing and ratifying decisions: To test the validity of a decision taken outside the group, or to ratify such a decision
- For co-ordination and liaison: To co-ordinate problems and tasks between functions or divisions
- For increased commitment and involvement: To allow and encourage individuals to get involved in the plans and activities of the organization.
- For negotiation or conflict resolution: To resolve a dispute or argument between levels, divisions or functions.
- For inquest or inquiry into the past

4.3 Multidiscipline Teams in an EPC Environment

Owing to the complex nature of EPC projects, a typical project requires the involvement and overlapping of various disciplines to provide the project deliverables such as drawings, bill of materials, equipment etc at different stages of the project. The whole set of project activities with defined objectives are fragmented among various disciplines and departments and a few are summarized in *table 4.1*. The sequence of execution for the three components of an EPC project is illustrated pictorially in *figure 4.1* for engineering, *figure 4.2* for procurement and *figure 4.3* for construction.

Discipline/Department	Service Specialization
Engineering Services	⌖ Define Scope of Work ⌖ Identify and Verify Technical Requirements ⌖ Detail Design ⌖ Process Engineering (Process Flow Diagrams, Process and Instrumentation Diagrams, Hazardous area classification, Piping and Valve Specifications, Instrument Index, Line List, Valve List etc.) ⌖ Mechanical Engineering (Equipment data sheets, Vendor coordination, Equipment drawings, Nozzle Specification etc.) ⌖ Piping and Layout Engineering (3D Model, Equipment GA and layout Drawings, Pipe support drawings, Plot plan, Isometric Drawings, Stress analysis report, Stress Isometrics, Preliminary, Bulk and final MTO, As built Model, Drawings and Documents etc.) ⌖ Structural/Civil Engineering (Civil and structural Design Calculations, Drawings, 3D Model, Fabrication Drawings, GA Drawing, MTO etc.) ⌖ Instrumentation and Controls Engineering (Instrument Index, Loop diagram and control schematics, Interconnection and control schematic, Logic diagrams, Technical Data sheets etc.) ⌖ Electrical Engineering (Equipment Specifications, MTO, Electrical Power layout, Cable Schedules, Cable Tray and Heat Tracing Layouts, Logic Diagrams etc.) ⌖ Technical Safety (HSE schedule and plan, safety system interfaces, TQ's to client etc.) ⌖ Shop and Follow-On Engineering ⌖ As-Built Documentation
Procurement Services	⌖ Procurement Plan ⌖ Supplier Scouting/Enquiries ⌖ Technical Clarifications ⌖ Purchasing ⌖ Supplier Negotiation ⌖ Expediting ⌖ Inspection Services

	⌖ Logistics
Construction Services	⌖ Method Input to Design ⌖ Fabrication ⌖ Piling, Foundation, Pipe Rack works ⌖ Pre-commissioning ⌖ Preparation and mobilization for Installation ⌖ Installation and Functional check of Mechanical Equipment ⌖ Tie-in with existing pipes ⌖ Hydro-Test ⌖ Calibration ⌖ Mechanical Completion

Table 4.1: EPC Component Specializations

Figure 4.1:Typical Service Sequence of Engineering

Figure 4.2:Typical Service Sequence of Procurement

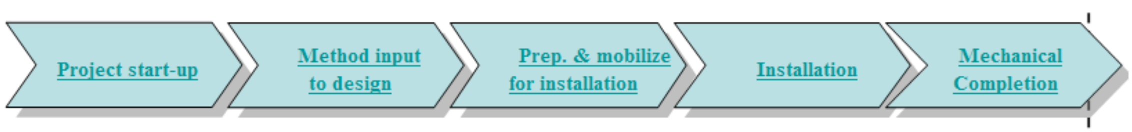


Figure 4.3: Typical Service Sequence of Construction

5 What is Integration?

5.1 Introduction

For any owner involved in an EPC contract, the objective is to extract the maximum economic potential. However experience has shown that this has been a challenge especially in large/complex projects and short-term alliance fast track projects. Today's EPC contracts follow the traditional bidding philosophies and alliance strategies in the form of risk and compensation sharing terms/agreements to promote owner objectives among the project participants (Lunde, Sirevaag and Tjaland, 1995). For the contractor, the contract comes with an inherent challenge to mobilize, streamline and coordinate timely completion of the scope and manage the orderliness of the Engineering, Procurement and Construction Disciplines. EPC contractors have been working with work processes and procedures over decades catering to the needs and the competency requirements of the market due to significant changes in terms of project duration and changes in technology. Not to mention the increase in client/customer power has been one of the drivers that ensure whether or not the relationships of the disciplines involved are optimally and sufficiently overlapped. From the contractor's point of view it is therefore important to map the dependencies between the main phases of the project (planning, design, procurement, construction) and within the project (across disciplines mechanical, process, piping structural etc) and resolve the gaps in communication, division of responsibilities and information transfer through a process of *Integration* and *Coordination*. But the question is, *'What is Integration?'*

- Is it an exchange of data between the Information Technology tools?
- Is it the means of communication between the project stakeholders?
- Is it the structure of the Organization that enables decision making?

Wagnalls (1973) defines integration as 'the bringing or fitting together of parts into a whole. 'Integrity is 'the condition or quality of being unimpaired or sound', and 'The state of being complete or undivided' Integral is defined as 'being an indispensable part of a whole; essential; constituent,' and 'formed of parts that together constitute a Unity'.

While Fischer et al. (1993) theory defines integration as means to accomplish success by broadcasting a complete new design version to all design participants for each design change, according to Khedro, Genesereth and Teicholz (1993), integration is *'A means of managing the information consistency as it is passed between applications by means of a central facilitator'*. Teicholz and Fischer, (1994), view integration as '*a competitive strategy and force for change in the engineering and construction industry'*.

The above definitions summarizes integration as a competency tool to enhance speed, accuracy, consistency and utility of shared informed in its use by successive project participants in the form of an 'intelligent automation' through information technology tools or system models. Even though the definitions above provide a knowledge of how and what information flows between the project participants, more specifically during the conceptual phase of the project, it still leave with an unanswered question *'How to defined integration in a not so technologically intensive basis of data/information sharing?'*

The definition provided by Fischer (1989) for design-construction integration as 'the continuous interdisciplinary sharing of data and knowledge between design and construction', introduces the concepts of sharing between functions, between disciplines, and through time. The definition identifies the internal characteristics of integration such as what/which knowledge, information or data is being shared. Owing to the characteristics of EPC work process, an extended definition of Fischer has been adapted in this research to address not only the integration with respect to the typical life cycle functions of the EPC project, but also to describe the mechanism of sharing (Multidiscipline Coordination).

5.2 Components of Integration

The components of integration *(see figure 5.1)* can be derived from the definition of integration with respect to the flow or exchange of data and information depending on their functionality as:

- Between Functions in the form of vertical Integration (Inter-functional)
- Between disciplines in the form of Horizontal Integration (Inter-Disciplinary)
- Through time in the form of Longitudinal Integration (Within project and project-to-project)
- Organisational Human ware in the form of human interaction mechanisms
- Technical in the form of hardware and software (Fergusson, 1993)

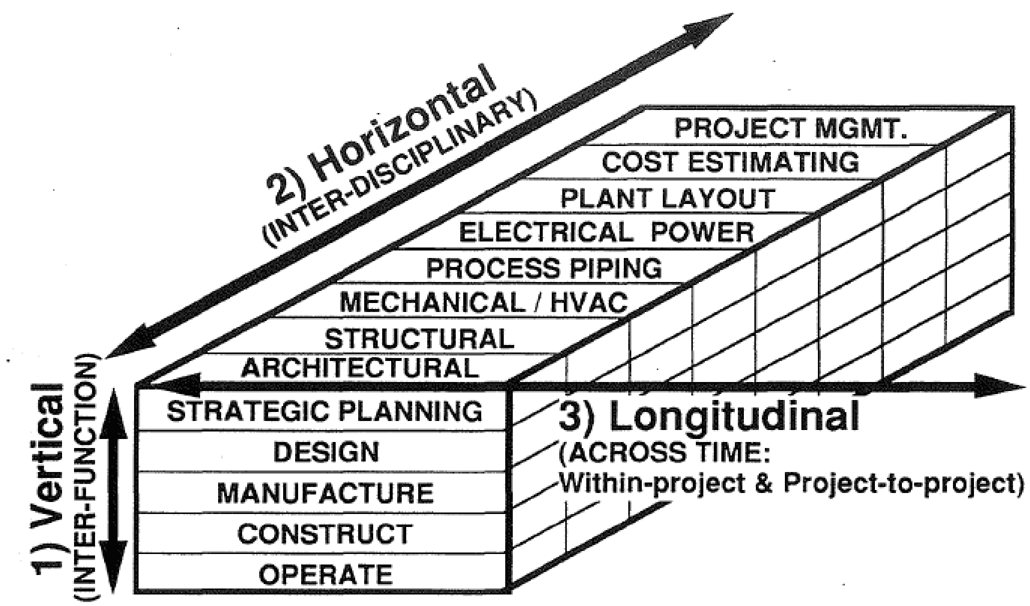


Figure 5.1: Vertical, Horizontal and Longitudinal Components of Integration

(Source: Fergusson, 1993, p.23)

5.3 Vertical Integration

The definition of vertical integration is often associated to economics and management and describes the organization's control or ownership of more than one function in the execution of project/projects. The functions in an EPC environment are tendering, project start-up, HES, Quality, Planning, Contract, Engineering, Procurement, Construction, Installation, and Completion. The functions are instantiated as participants in the form of individuals or teams for a project. The vertically integrated structure is a single legal entity which is responsible to perform one or all of these functions internally by exercising control through ownership. Some of the key characteristics of vertical integration stated by Thomas (1992 cited in Fergusson, 1993) are

- Sequential progression from function to function as the project progresses from the time of conception to operation
- Sequential timing providing linear thinking modes of operating a project and thus helps focusing on the project execution

- Partnering of functions enabling a common stake in the success of the project especially in large and complex projects
- Analyzing the integration of various functional knowledge and their dependency

5.4 <u>Horizontal Integration</u>

Unlike vertical integration, the horizontal integration is characterized by having no precedence in the ordering of the engineering disciplines. The horizontal integration is applicable to the engineering services especially in detail engineering by architecture, structural, mechanical, process and piping disciplines. Davis, Ledbetter and Burati (1989), define the horizontal type of organization as integration *'in which two or more similar concerns are combined to perform the same functions in the same stage of distribution or production'*. There is high degree of information flow and dependency between the participating disciplines in the project execution. This type of integration dwells in the exchange of information between applications, accessing or sharing information from a common repository, generating new information like cost estimates using existing information and experience.

5.5 <u>Longitudinal Integration</u>

In a longitudinal integration model, the flow of information is spread across two major time horizons: one within the project time horizon and the other from project-to-project time horizon. In a project time horizon, the flow of information is within the project from the initiation to the hand-over of the deliverable. In a project-to-project time horizon, the flow/exchange of data/information is from the previous projects or concurrent projects or future projects. The longitudinal integration is characterized by three different areas of organizational literature as organizational learning, cycle times and quality management. Longitudinal integration is a means of reducing the cycle time and enhancing the efficiency of project execution by retaining the lessons learned based in a knowledge reservoir from previous and current projects. The more the EPC contractor focuses on refining the work processes iteratively, the faster and smoother is the execution of the flow of knowledge and information.

6 What is Coordination?

6.1 Introduction

The EPC sector has been reinventing over the years with the implementation and use of technologies aimed at bringing down the costs of transacting between any two elements, two individuals or two applications. Owing to the high dependencies between people and technologies, the medium of transacting has become a key success factor to the organizations to exchange or communicate information beyond their physical boundaries. With goals to focus on innovation in one hand and to maintain focus on interdisciplinary transaction on the other hand, it makes necessary for an organization to accommodate or experiment with the new technologies to transport intellectual information. Going by the intuitive meaning, coordination can be simply understood as a means of transacting. But when we rope in the fundamentals of organizational theory and various disciplines involved (both horizontally and vertically in the project) and their inter/intra dependencies, the definition provided by Mintzberg (1983) *'as a direct consequence of the necessity to divide the labour in an organization into various tasks'* can be the best adapted.

6.2 Organisational Human Ware Coordination

All activities that involve more than one actor require (1) some way of dividing activities among the different actors and (2) some way of managing the interdependencies between the different activities (March and Simon, 1958; Lawrence and Lorsch, 1967). *Table 6.1* and *figure 6.1*explains the five vehicles proposed by Mintzberg (1983) that drive the human ware coordination to manage the flow of knowledge and information between the vertical, horizontal and longitudinal integration levels.

Mechanism	Properties/Characteristics
Mutual adjustment by informal communication	Information exchange is basically among the members of a team and organisation oriented towards each other's goals and dependencies through scheduled meetings agreed upon mutually
Direct supervision	Coordination through physical presence governing the activities/processing steps to be executed by the subordinates or assigning tasks
Standardisation of work processes	Coordination managed by standard work processes or common practices to avoid complexities and conflicts
Standardisation of the output	Coordination through drawings or reports etc adhering to the quality and standard practices
Standardisation of skills	Coordination through competencies and certifications
Implicit Coordination	Implicit coordination is the anticipation of the actions and needs of team members and task demands, and dynamic adjusting of their own behaviour accordingly, without prior plan of activity or communicating with each other (Cannon-Bowers et al. 1993).

Table 6.1: Vehicles of Humanware Coordination between Vertical, Horizontal and Longitudinal levels of Integration

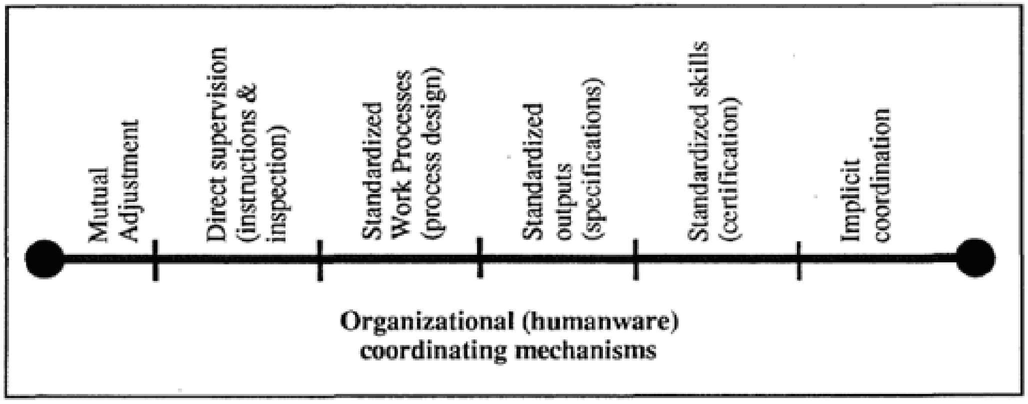


Figure 6.1: Humanware Coordinating Mechanisms

(Source: Fergusson*, 1993, p.37)*

6.3 Technical Coordination

The definition of Organizational Human Ware Coordination is limited to the flow and exchange of information between the people and teams (disciplines) in the organization/project. With the advent of new information and communication technology tools, a new means of coordinating opportunities have evolved in the form of technical coordination. Technical coordination for information and knowledge flow is governed by the use of hardware and software tools as shown in *figure 6.2*. These tools can be 3D CAD models, 2D Drawings, document control systems, e-mail, telephone, reports etc. These tools serve as a means to coordinate but in no way guarantee the amount or quality of information and knowledge that flows. The properties or results of the coordination can be non-determinant due to the operator or human reliability which in turn is affected by his/her capabilities, psychological and cultural characteristics of the operator and the overall system's design.

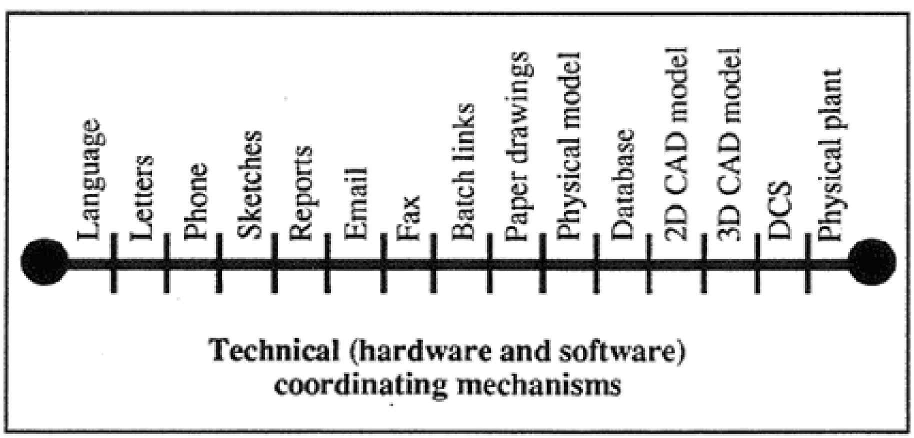


Figure 6.2: Technical Means of Coordination

(Source: Fergusson*, 1993, p.39)*

7 Measurement of Integration and Coordination

7.1 Framework of Integration and Coordination

Based on the definition of EPC contract and its stratified execution pattern, the three dimensions of integration namely Vertical, Horizontal and Longitudinal and the two dimensions of coordination mechanism namely technical and organizational coordination can be summarized in a framework as shown in *figure 7.1*. The framework is strictly based on the operational structure, limiting the flow of information end long with respect to time. The operational structure in a horizontal functional flow of information is parallel with respect to time and thus performs simultaneously.

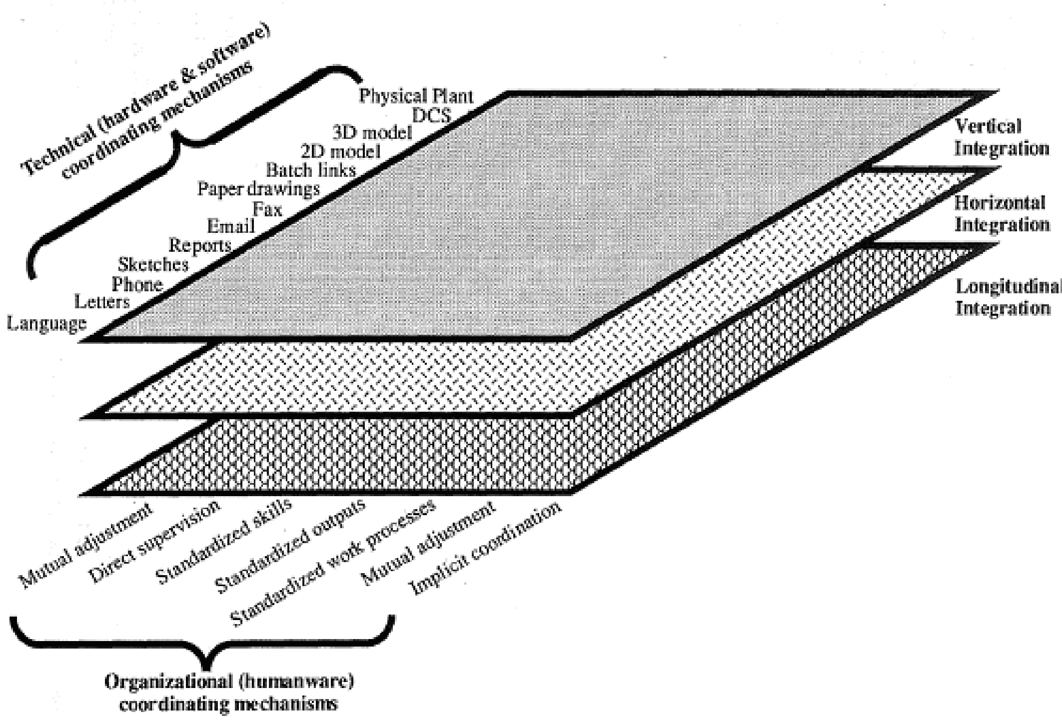


Figure 7.1: Framework of Integration and Coordination

(Source: Fergusson*, 1993, p.42)*

7.2 Why to Measure Integration?

Due to the complexities in EPC project execution colligated with the significant risks associated to both the contractor and the owner, it is important to understand and measure the various overlaps represented in the form of *'Interdependence'*. *Interdependence* is the relationship between two or more units that are mutually and exclusively affecting each other or being affected. Today's organizations resort to sophisticated and complex technologies in order to provide the goods and services necessary to the client. There is an element of risk associated with the contractor due to extensive interdependence, tight coupling and unpredictability between the partially autonomous and interactive structural levels like infrastructure, socio-structure, functions, disciplines and superstructure.

Interdependence can lead to complexities to a degree to which it cannot be foreseen and the multiple interactions can hinder project success and sometimes lead to accidents. This is primarily because of many interdependent and shared systems that require integration and coordination, along with continuous monitoring of the interdependent systems. The accidents can be attributed to the impracticality or failure of implementing various tasks of modelling socio-technical and operational interdependencies.

With the development and expansion of organizations, the number of communication and technological links increase marking ways to make interactions more complex. Interactive complexity consists of two dimensions.

- High interactive complexity refers to processes of 'unfamiliar, unplanned and unexpected sequences, and either not visible or immediately comprehensible'.
- Low interactive complexity refers to 'expected and familiar production or maintenance sequences, and those that are quite visible even if unplanned'.

Tight coupling refers to the amount of slack or buffer that exists between system components and ranges from high to low. High tight coupling implies that there is picayune slack or buffer within the system with no possibility to delay processing, while low tight coupling refers to excess slack, buffers or time. The greater the degree of complexity of interdependence and coupling, the greater is the likelihood an accident is waiting to happen (Perrow, 1984). Although the work of Perrow (1984) is associated with high risk organizations, the definitions of interdependence, high/low interactive complexity, tight coupling, buffer and slack have been adapted in this research to emphasize the significance of measurement of integration required to achieve project and organization success. The term high risk organization has been associated to both the contractor as well as the owner because any under designed quality or inferior grades of material installed can lead to accidents to the personnel in operations environment of a plant facility. For an EPC contractor the risk factor is even higher as it is his responsibility to ensure site safety upon delivering the scope of work and is solely responsible for the general insurance liability and compensation in case of an accident.

8 What is Performance Measurement?

8.1 Introduction

The success mantra of today's businesses or contractor's is to clearly define goals, establish directions to achieve the goals and take decisions as necessary to be competitive and profitable. In order to achieve the aforementioned, it is necessary for the organization monitor their current state of core competence and their behaviour in the business area of interest while sprinting in the direction of achieving the goals. With increasing number of concurrent projects being executed, it is difficult for an organization to gauge the current state of organizational capabilities/deficiencies and therefore cannot control its behaviour all alone. Therefore it becomes imperative that the management and the decision makers in an organization acquire tools or programs to monitor and report the ongoing accomplishments and challenges while moving towards the defined and pre-established goals.

The United States General Accounting Office (2005) provides a comprehensive definition of performance measurement: 'Performance measurement is the ongoing monitoring and reporting of program accomplishments, particularly progress towards pre-established goals. It is typically conducted by program or agency management. Performance measures may address the type or level of program activities conducted (process), the direct products and services delivered by a program (outputs), and/or the results of those products and services (outcomes). A program may be any activity, project, function, or policy that has an identifiable purpose or set of objectives'.

The program can be any activity, project, function, or policy that has an identifiable purpose or a set of objectives. The upshot of the entire program is defined as *Performance Measurement*. The program works on the output results and the outcomes obtained from program permit evaluation and comparison vis-à-vis goals, standards, historical results and other organizations. The reporting part of the program refers to numerical information that quantifies input, output, throughputs, impact and performance dimensions of processes, products, services, and the overall organization (outcomes).

Inputs is defined as all the required stimuli necessary to accomplish a certain task/activity or execute a project in the form of initiating the requirement of man power, machinery/information technology tools, materials etc. In an EPC project these inputs comprise of start up plan, identification and formation of teams, delivery schedules, scope of work, expectations from stakeholders etc.

Outputs in simple terms are defined as the quantified amount of work performed or number of activities completed or a measure of delivered services. Outputs measure the success of the individuals, disciplines, management, projects and therefore become the basis of existence for an organization.

Both Inputs and Outputs are mutually dependent on each other and measure the efficiency of a project. The more closer or optimum the relationship, the more is the successes the organization can achieve. Examples of outputs are 2D drawings to construction, bill of materials to procurement, 3D model to the client etc.

Throughputs are defined as the means or catalysts that should be a part of the organization to inclose the gaps between the inputs and outputs. The effectiveness of the catalysts or means determine the efficiency and effectiveness of the organizations operations. Example of throughputs are work processes, quality practices etc.

Outcomes are associated with the organization's goal and evaluates whether or not the organization is pursuing its goal in the short-term or long-term. Examples of outcomes are innovation, unique competency, increased market share, stakeholders satisfaction etc.

Impact is defined positive or negative changes that come into existence as a result of organizations new goals (short-term or long term) or implementation of new strategies. One of the examples is the affect of adapting 3D applications over 2D on the projects (United States General Accounting Office, 2005).

8.2 Why Performance Measurement?

Performance measures came into existence to help the businesses to proctor the current capabilities and find out whether they are moving in the right direction as defined by the business goals and objectives. These measures serve the management to gauge the progress in alignment with the vision of the stakeholders (projects, employees, clients etc). Administering management with performance measures is a kind of a strategy that essentially meets the needs of the stakeholders through different independent and dependent processes but aligned to meet the business goal.

The performance measurement helps businesses in periodically setting business goals and then providing feedback to managers on progress towards those established goals. The measurement helps on how to analyze and evaluate a range of information to manage resources and make decisions about the future direction of the organization strategically. It is often that the results presented by the program or the agency are massive and majority of it may or may not be of direct relevance to the managers. In order to distribute the information or the results in a way that can be easily interpreted or more relevant to the management once need a control system. When the results of the program or the agency are available or being measured, the firm can define an alert or alarming system on the performance measurement output parameters to diagnose the problem and take an action to find a solution. These alerts help the organization or the businesses to have control over the progress made and target the areas of concern or areas on insufficient success. These alerts will help the management to initiate the decision making process strategically. The systems that facilitate these alerts are defined as the Control Systems (Neely, Adams and Kennerley, 2005).

The Performance-Based Management Handbook (2001) from Performance-Based Management Special Interest Group, enlists the following reasons as to what performance measures can do

- Allows the organisation to know their current status of competency
- Provides a means to know if the organisation goals are meet
- Provides the means of effectuation as to whether the customers are satisfied with the services or not
- Entails whether the operational processes are in statistical control or not
- Implies as to whether improvements need to be initiated and if yes where those improvements need to be initiated
- According to Procurement Executives Association Office of Procurement and Assistance Management, US Department of Energy (Procurement Executives Association, 1999), performance measurement system must be an integral part of an organisation's business processes as
- They measure the progress made by the organisation in achieving the goals and objectives.
- They measure and indicate the required resources, helping the business process executives to determine the required appropriation level.
- They help to prioritise the goals for the organisation to focus on efforts need to achieve them.
- They present the negative variances of performance targets that need to be addressed.
- The results from the measures can be used to estimate and quantify the budget allocation
- They help to effectively and efficiently monitor the business operations.
- They provide an opportunity to focus on the future plan of action.
- They establish cause and effect relationships between the organisation, efforts, performance and costs.

8.3 Performance Measurement Framework

Many researchers have proposed motleyed performance measurement frameworks like Integrated Performance Measurement System by Performance-Based Management Special Interest Group (2001), Balanced Scorecard by Kaplan and Norton (1992), Measurement Linkage Model by Chang and DeYoung (1995), Strategic Measurement Model by Mark Graham (1999) etc. The following literature provides the features of all the four models investigated as part of this research.

8.3.1 Measurement Linkage Model (MLM)

Measurement Linkage Model was designed by Chang and DeYoung (1995) to enable a discipline/department/division in an organization to develop a performance measurement framework of their own through Key Result Areas (KSA) and Key Indicators (KI).

Key Result Area is defined as a 'critical, 'must achieve', 'make-or-break' performance category for an organization' (Chang and DeYoung, 1995, p.l7).

Key Indicator or KI is defined as 'a metric by which an organization can evaluate achievement toward its KRAs' (Chang and DeYoung, 1995, p.18).

The conceptual framework proposed by Chang and DeYoung (1995) for a disciplined approach to performance measurement consists of eight steps:

Step 1: Develop Organization-Wide KRA's, KI's and Performance Targets

Step 2: Select Organization-Wide KRA's and KI's linked to Your Work Group

Step 3: Develop Work Group KRA's

Step 4: Develop Work Group KI's

Step 5: Determine Data Collection, Tracking, and Feedback Methods

Step 6: Gather Baseline Data and Set Performance Targets

Step 7: Establish Work Group Objectives and Tactics

Step 8: Implement Plans, Monitor Performance, and Provide Feedback

The feedback as a result of implemented plans or strategy from step-8 is used to re-orient objectives of the work groups, paving way for continuous improvement.

8.3.2 Integrated Performance Measurement System

The Integrated Performance Measurement System designed by Performance-Based Management Special Interest Group in their book Performance-Based Management Handbook (2001) integrates the relationship between the stakeholders or participants in an activity by measuring their performance against what is expected of them and what they are responsible for. Integrated Performance Measurement System consists of nine critical components as described in *table 8.1*.

Critical Component	What is done?
Strategic Plan	⌖ Performance measures are linked to strategic plans that are necessary for the organisations to remain successful over longer periods of time. ⌖ Performance measures to be monitored are defined and are mapped against

	the group or individuals who own it
Key Business Processes	⌖ Identify the key business processes that impact the strategic plans
Stakeholders	⌖ Identify the stakeholders who are directly or indirectly related to the outcomes of an organisation. The stakeholders should include people who provide output to their dependents or the people who they receive input from.
Senior Management	⌖ Senior management is involved to promote performance measurement initiatives by delegating responsibilities, by leading by example, by establish good communication processes and by seeking feedback
Balanced Set of Measures	⌖ Identify different categories of data required ⌖ Categories are balanced taking into consideration the expectations and needs of respective groups
Critical Few	⌖ All the data that is not necessary or can distract management is filtered out retaining only few critical measures that logically state organisation success
Accountability	⌖ The managers and the team members are educated about the responsibility and accountability of the performance measures
Vertical Integration	⌖ Implement the performance measurement system at each level of the organisation matrix and ensure that the measures are aligned to the strategic plans
Horizontal Integration	⌖ Ensure that the work boundaries are not hindering the implementation of performance measures ⌖ Ensure that focus on the client is maintained continuously

Table 8.1: Components of Integrated Performance Measurement System

8.3.3 Balanced Scorecard

In 1992, Robert Kaplan and David Norton introduced balanced scorecard concept as a means of collecting the measures and enable managers to use the measures to strategize and implement plans. *Figure 8.1* illustrates the balanced scorecard from four perspectives.

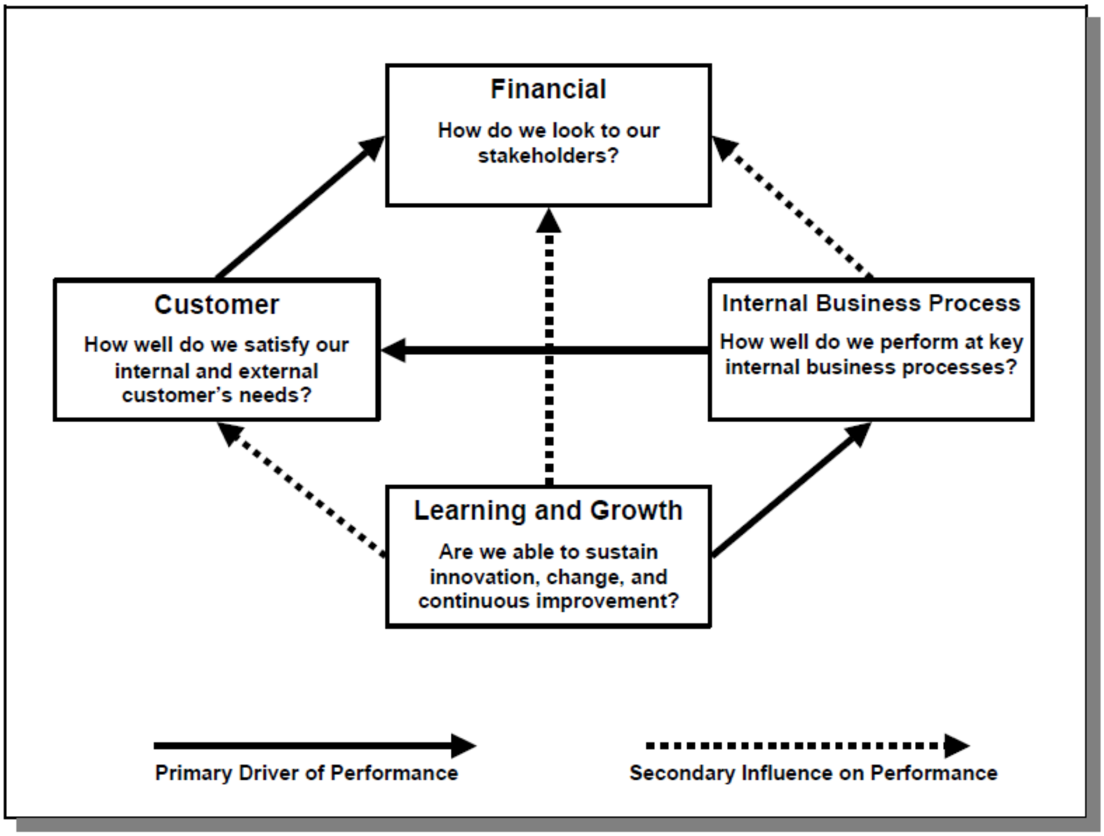


Figure 8.1: Four Perspectives of Balanced Scorecard

(Source: Performance- Based Management Handbook, 2001, p.20)

Each perspective is linked to the other through a cause and effect relationship. The framework focuses upon the results of measures within the process and simultaneously takes into consideration the factors that are affecting them externally. Due to interdependence of each process any significant negative impact on one function on the other as a result of desired outputs is avoided. The Balanced Scorecard model primarily focuses on the financial perspective as a starting point by developing strategic plans from the eyes of shareholders or market and then defines the necessary financial objectives. The financial objectives motivates the other three perspectives: to see from the eyes of a client or customer, review the business processes to focus on areas of weaknesses or concern and search for opportunities or areas to improvise operational performance(Performance- Based Management Handbook, 2001).

8.3.4 Strategic Measurement Model

Mark Brown, in 1996, introduced the strategic measurement model that focuses only on the measures that an organization views as critical. According to Brown (1999), the strategic measurement model is a six step process as described in the *table 8.2*.

Measurement Phase	What is done?
Preparing Guiding Documents	⌖ Establish organisations mission and vision for the future
Situation Analysis	⌖ Identify organisations strengths and weaknesses relative to the

	market competitors ⌖ Anticipate the trends that could potentially impact or hinder organization's mission and vision from achieving
Key Success Factors	⌖ Identify and define the key success factors that separate the organisation from its peers or competitors
Macro Performance Measures	⌖ Identify and categorise measurement categories into short-term and long-term measures ⌖ Ensure that the work group have identified all the possible metrics for each category and are linked directly to the key success factors ⌖ Filter down all the measures to a critical few so that they can be easily managed and successful to operate
Measurement Plan	⌖ Identify the data collection method for the measurement. ⌖ Specify the frequency of data collection ⌖ For each measure map the responsibility or ownership ⌖ Identify and map the links to the key success factor for each metric
Data Collection Instruments and Procedures	⌖ Identify the means of data collection (through an external agency or through a procedure)

Table 8.2: Six-Step Strategic Measurement Model

8.3.5 Summary of Framework Models

Based on the four models surveyed, it can be interpreted that all the models have a similar outline and sequence. The similarities in the performance measurement framework models discussed and examined are henceforth summarized in five steps.

Performance Measurement Framework Model	**Objective**
Measurement Linkage Model (MLM)	⌖ Develop and Select Organisation Wide Key Research Areas, Performance Targets
Integrated Performance Measurement System	⌖ Critical Component - Strategic Plan
Balanced Scorecard	⌖ Primarily focuses on the financial perspective as a starting point by developing strategic plans from the eyes of shareholders or market and then defines the necessary financial objectives
Strategic Measurement Model	⌖ Preparing Guiding Documents

Table 8.3: Objective Vs Performance Measurement Framework Model

Performance Measurement Framework Model	Key Processes
Measurement Linkage Model (MLM)	⌖ Develop and Select Organisation Wide key research areas linked to the work group
Integrated Performance Measurement System	⌖ Key Business Processes: Identify the key business processes that impact the strategic plans
Balanced Scorecard	⌖ Internal Business Process/ Customer Perspective
Strategic Measurement Model	⌖ Key Success Factors

Table 8.4: Key Processes Vs Performance Measurement Framework Model

Performance Measurement Framework Model	Stakeholders
Measurement Linkage Model (MLM)	⌖ Develop and Select organisation wide work groups
Integrated Performance Measurement System	⌖ Critical Component - Stakeholders
Balanced Scorecard	⌖ Internal Business Process/ Customer Perspective
Strategic Measurement Model	⌖ Macro Performance Measures / Measurement Plan

Table 8.5: Stakeholders Vs Performance Measurement Framework Model

Performance Measurement Framework Model	Metrics
Measurement Linkage Model (MLM)	⌖ Develop Organization-Wide Key Indicators ⌖ Select Organization Key Indicators linked to Your Work Group ⌖ Develop Work Group Key Indicators
Integrated Performance Measurement System	⌖ Critical Component - Balanced Set of Measures ⌖ Critical Component - Critical Few
Balanced Scorecard	⌖ Internal Business Process/ Customer Perspective
Strategic Measurement Model	⌖ Macro Performance Measures

Table 8.6: Metrics Vs Performance Measurement Framework Model

Performance Measurement Framework Model	Implementation
Measurement Linkage Model (MLM)	⌖ Determine Data Collection, Tracking, and Feedback Methods ⌖ Gather Baseline Data and Set Performance Targets
Integrated Performance Measurement System	⌖ Accountability ⌖ Vertical Integration ⌖ Horizontal Integration
Balanced Scorecard	⌖ Internal Business Process/ Customer Perspective
Strategic Measurement Model	⌖ Measurement Plan ⌖ Data Collection Instruments and Procedures

Table 8.7: Implementation Vs Performance Measurement Framework Model

8.3.6 Strengths and Weaknesses of Performance Measurement Framework Models

Most of the companies use versatile strategies and techniques at different levels of an organization to fortify their competence in the fields of continuous improvement, planning, information technology, organizational culture, innovation, employee empowerment etc. In the frameworks examined, the focus of the customer has been explicitly defined for the analysis and improvement of organization performance but none of the frameworks describe a methodology to define balanced measures suitable for the dynamic EPC project. *Table 8.8* illustrates the strengths and weaknesses of the frameworks surveyed.

Performance Measurement Framework Model	Strengths	Weaknesses
Measurement Linkage Model (MLM)	⌖ Integrates organisation objectives with operational performance measures ⌖ Focus on the most important drivers that leads to success of an organisation ⌖ Includes all the responsible stakeholder groups ⌖ Focuses on mapping the relationships between stakeholders	⌖ Not driven by financial results or focus on customer ⌖ Relationship among the measures is not defined ⌖ Can promote local optimisation of business processes leading to an imbalance of parallels ⌖ Does not take the scope and trends into consideration ⌖ Do not explicitly define the cause and effect relationship which could cause to modify the structure upon deployment
Integrated Performance	⌖ Integrates organisation objectives with operational performance	⌖ Do not explicitly define the cause and effect relationship which

Measurement System	measures ⌖ Explicitly Includes all the responsible horizontal and vertical stakeholder groups	could cause to modify the structure upon deployment ⌖ No methodology to define the relationships ⌖ Does Not explicitly integrate the concept of continuous improvement ⌖ Do not take the scope and trends into consideration
Balanced Scorecard	⌖ Integrates all the key performance measures (strategic, operational, financial and continuous improvement) ⌖ Emphasises focus on the relationships, links and strategy maps ⌖ Widely accepted framework	⌖ Too much focus on customer and financials results ⌖ Designed for top management to gather information about their performance and hence is not widely accepted at operational level ⌖ Not applicable to complex organisations that look beyond the four perspectives ⌖ Do not take the scope and trends into consideration
Strategic Measurement Model	⌖ Takes trends and future market scenario's into consideration ⌖ Comprehensively includes all the stakeholders into consideration ⌖ Focuses on the key drivers necessary to achieve the objective	⌖ Does not explicitly identify and define the relationships between the performance measure ⌖ Does not explicitly integrate the concept of continuous improvement ⌖ Can promote local optimisation of business processes leading to an imbalance of parallels

Table 8.8: Strengths and Weaknesses of Performance Measurement Framework Models

9 METRICS DEVELOPMENT

9.1 Introduction

According to Neely, Adams and Kennerley (2005), the responsibility of a good performance measurement system is to present all the required information or data to the management or business in such a way that the data can be intelligibly interpreted and can lead to taking accurate decisions. Measures developed through brainstorming exercises can motivate people to consider all the possibilities. However, such an effort can lead long stacks of measures. Success of the measurement model relies on the integration so that performance measures can be effective agents to enable a change or implement an improvement policy (Performance- Based Management Handbook, 2001).

9.2 Researcher's Measurement Model

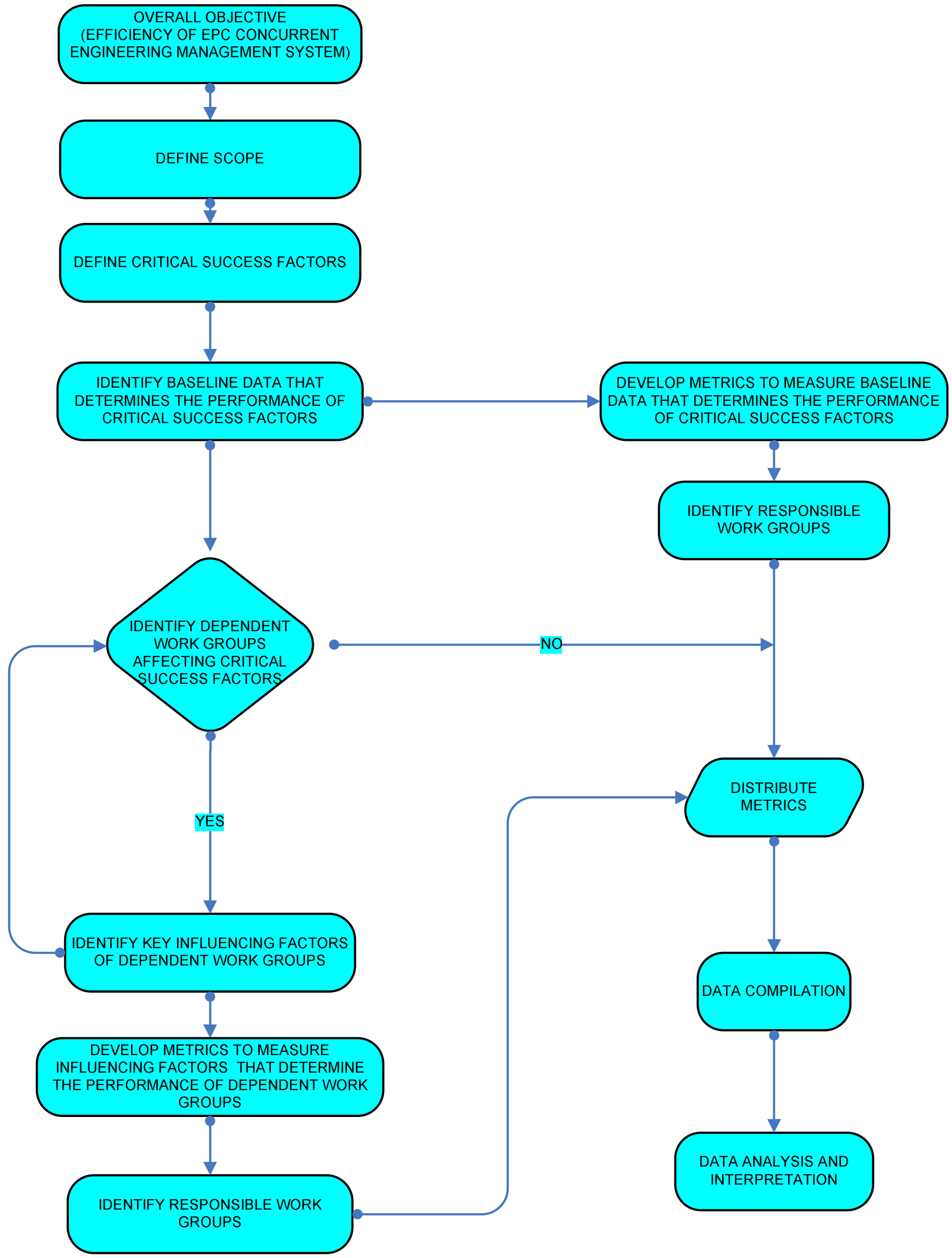
The first and foremost stride in developing and deploying a good performance measurement system is to design the performance measures. The primary objective of the design stage is to firstly understand what parameters needs to be measured or monitored and secondly define a procedure or a process as to how the required parameters would be measured. The motive in the design stage is to address the challenge of taking decisions on *what to measure* and *how to measure*. It is certain that one can get any information or data the performance measurement system is measuring but the prima facie oppugn are whether right behaviours or characteristics are measured or not. It is often that businesses tend to pick the behaviours that are easy to measure instead of finding out what is important to measure. This will lead to inappropriate data and hence leads to incorrect decisions (Neely, Adams and Kennerley, 2005).

When a performance measurement model is to be developed or adapted, a comprehensive survey of the models in use can provoke, motivate and stimulate new thoughts on what is required to be measured. In order to develop one's own (customized) performance measurement framework for the first time, it is important that the thoughts are organized and a common vocabulary is adapted.

Because none of the frameworks studied and examined in *chapter 8* exactly fit into the needs of the organization/research unit, the ideas and approaches from the models surveyed have been used to develop a framework suited to the current organizational environment (DOE 1996). Another motivation to develop an adapted approach is that none of the frameworks discussed in this research do not define the external environment or the scope of project that is affecting the performance of the organization. The EPC contracts vary both in complexity, degree of client's participation, type of contract etc and hence have to be taken into consideration to develop a framework suited to all the factors affecting the project success. Owing to the non-availability of extensive research or literature specific to the EPC industry meeting the kind of portfolio of projects being handled, the researcher derived a conceptual 12 step performance measurement framework model and is presented using a flow chart in *figure 9.1.*

1. Define Scope
2. Define Critical Success Factors that will ensure successful competitive performance of the organization by observation, literature review and interviewing the key personnel in the research unit
3. Identifying the focus groups (project management group, planning work group, team leads etc.) for each critical success factors
4. Discuss the manifestation of the content with the focus groups informally and through weekly meetings
5. Develop metrics and gather baseline data that best gauges the status of the Critical Success Factors of the research unit based on discussion in step-4.
6. Discuss and evaluate the factors that are influencing or affecting the critical success factors (key influencing factors) with the focus groups

7. Identify the research work groups who are accountable for the factors influencing the critical success factors
8. Identify the research work groups who are getting affected (dependent work groups)
9. Develop metrics to measure key influencing factors that determine the performance of critical success factors identified in step-2
10. Identify work groups for the implementation of metrics
11. Gather responses (data collection)
12. Analyze data and interpret



<u>Figure 9.1: Reasearcher's Measurement Model</u>

9.3 Defining Scope

Before proceeding to the actual measurement of integration and coordination, it is important to define the scope. The scope in this research defines the context and a boundary within which the measurement is applicable to and is defined by the characteristics of the business the organization is into. The scope outlines the type of projects the organization has handled or is intending to venture in the future and their characteristics such as:

- Average budget of the projects
- Owner's participation in the project
- Type of project (Maintenance projects/Modification projects/Green Field projects etc)
- Complexity of the project (with respect to unproven technology or inexperience in the project scope of execution)
- Types of Contracts Usually Negotiated (Cost Reimbursable or Cost Plus, Unit rate or Unit Price, Fixed Price, Lump Sum Price)
- Types of Delivery Methods (Engineering Services, EPC Services, EPCIC Services, Construction Management etc)
- Types Of incentive Schemes Usually Negotiated (Target Hours Incentive, Quality Incentive, Weight Incentive etc)

9.4 Critical Success Factors

The concept of critical success factors was first introduced by John F. Rockart and the MIT Sloan School of Management in 1979 to empower senior executives to define their information needs for the purpose of managing their organizations (Rockart, 1979). Daniel had discussed the problem of inadequate management information system for setting up objectives, shaping strategies, making decisions, and measuring results against goals. Supplementing to the ideas on 'success factors' introduced by D. Ronald Daniel in 1961, Rockart (1979) proposed the critical success factors concept to help organizations and top management to identify their own needs for information about issues that were critical to the organization, so that systems could be developed to meet those needs and demands. Critical success factors are *'the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization'* (Rockart 1979, p. 85). Rockart further defines the critical success factors as cardinal identifiable areas where favourable results are absolutely necessary if management goals are to be reached. Another way of adverting critical success factors is key success factors although the later is more used in strategic planning. According to Grunert and Ellegard (1993), the term has been used in basically four different ways:

- As a (necessary) ingredient in a management information system
- As a unique characteristic of a company (core competency of the organisation)
- As a heuristic tool for managers to sharpen their thinking
- As a description of the major skills and resources required to have a successful performance in a given market

Although the work of Rockart does not specifically talk about the ways in which the critical success factors can be enforced, he did note that they can be used or extended to other practical purposes. In either case, the CSF's or KSF's provide a means to the management to define the metrics necessary to understand the current position of the firm's performance based on objectified characteristics and focus on the skills and resources that have to be implemented. The definition provided by Rockart, emphasizes to focus on only on the internal factors governing the objectives and does not take into consideration the external environment. But according to Leidecker and Bruno (1984), CSF are 'those characteristics, conditions or variables that, when properly sustained, maintained, or managed, can have a significant impact on the success of a firm competing in particular industry'. The work of Leidecker and Bruno extends the application of critical success factors beyond the boundaries of the organization to enhance organization's competency in the market when competing with peers. The definition by Pinto and Slevin (1987) *'factors which, if addressed, [would] significantly improve project implementation chances'* provides an opportunity to perform gap analysis at an operational level.

9.4.1 Project Performance

The performance of a project is governed by three goals to deliver the scope on time (Schedule Goal), within the budget (Cost Goal) and to the right specification/quality (Quality Goal). Even though the quality goal is attributed to the project execution and delivery phase, it has been linked to the project performance as the quality of policies governing the cost and schedules have significant affect. The goals to be achieved are dependent on the organization policies with respect to the budget estimates, cost estimates and quality procedures. An important bi-product that is harvested as a result of meeting the goals is to win client's goodwill and meliorate future potential opportunities.

In an EPC contract, the planning and budgeting discipline develop a cost breakdown structure (CBS) that include all the elements or activities or processes contributing to the project budget. The CBS is superimposed on the work breakdown structure of the project that delivers services to produce a tangible or intangible product. Progress evaluated by schedule and cost of the project is monitored by the developments in activities that produce tangible products like 2D isometric drawings, Structural drawings, specifications, documents, reports etc. The efficiency of planning and control depends on how well the whole project scope is organised into manageable modules or areas or building blocks or systems. The success of CBS depends on WBS as the later takes not only into account the activities that produce a tangible deliverable but also the supporting services that enable them to do so. The WBS extends from horizontal disciplines to vertical disciplines in the form of work packages through bill of materials for purchase by procurement and sufficient documentation necessary for the yard or construction site to fabricate/install.

The project schedule on an EPC project is supervised using the engineering milestones (milestones to deliver engineering drawings, bill of materials etc) and through the work package completion by the procurement and construction discipline. Due to the dependency of work packages, the procurement and construction disciplines govern the need dates for engineering.

The success of delivering the project on time depends upon the colligated synchronization of engineering disciplines (horizontally with respect to time) and their timely transfer of work packages to procurement and construction. Another success factor for good project schedule control is the integration and balancing of all the participating disciplines and their associated activities through logical network trails. The recorded baseline metrics for the critical success factor project performance is presented in *table 9.1*.

Key Indicator	Access What?	Responsible Work Groups	Research Population
Project cost	⌖ Actual Cost Vs Estimated Cost	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders
Project schedule	⌖ Actual Schedule Vs Estimated Schedule	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders

Client satisfaction	⌖ Customer Satisfaction Rating	⌖ Project Management	⌖ Project Manager
Scope	⌖ Project Complexity Vs Contractors Competency	⌖ Contractor or Organisation	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders
Incentive schemes	⌖ Incentive Schemes banked or not banked by the project	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager

Table 9.1 Metrics for Project Performance

9.4.2 Front End Planning/ Start-Up Plan

Construction Industry Institute (2006), defines the Front End Planning (FEP) as 'the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project' (p. 1). Front end planning reduces the risk associated with the two critical factors: project execution cost and schedule overrun. With an effective front end planning, the project cost can scale down by 20% (Construction Industry Institute, 1995). Figure 9.2 demonstrates the influence of front end planning on the project expenditure (Construction Industry Institute, 1997). The front end planning is also referred to as conceptual engineering or feasibility analysis, pre-project planning etc. According to Griffith and Gibson (2001), front end planning takes a holistic view of the participation of all stakeholders in the vertical, horizontal and longitudinal hierarchal levels of the project execution.

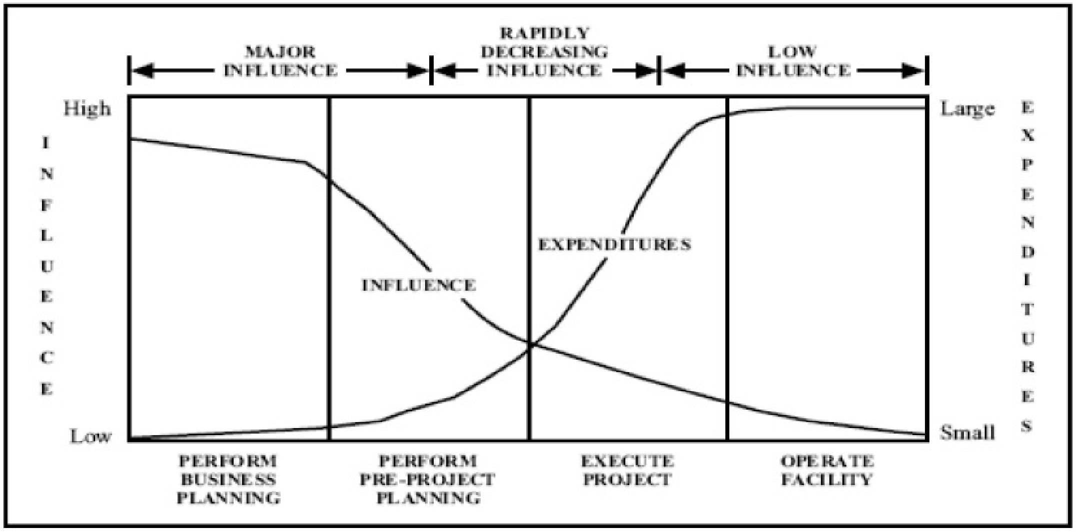


Figure 9.2: Influence of Front End Planning on Project Expenditure

(Source: Construction Industry Institute, 1997)

Once the contract has been awarded, the project moves into a very brief phase of the lifecycle of the project called project start-up. The start up plan is an important intermediate activity between the phase of contract award and phase of project execution. A few important activities during this phase are

- To define the project objective, scope/parameters and statement of work (SOW)
- To identify the potential sources of risk and take proactive actions to mitigate or establish contingency plans
- To develop the work breakdown structure
- To establish a project organization structure
- To develop a baseline plan for schedule and milestones
- To establish activity network
- To identify ,mobilize and commit the required resources in the form of people and technology into the project
- To establish the milestones to be tracked and the desired format to gather the information
- To establish change management methodology
- To establish Risk Management methodology
- To defining the roles and responsibilities of the project team
- To define tools and standards to be used in the project

Most of the EPC contractors typically use start up checklists to keep track of start up activities prior to the execution and it is the responsibility of the project manager to ensure that all the required and concerned items are marked off. The recorded baseline and key influencing factor metrics for the critical success factor Front End Planning/start-up plan is presented in *table 9.2*.

Key Indicator	Access What?	Responsible Work Groups	Research Population

Organisation policy	⌖ Organisation policies/procedures that govern the budget/schedule estimates for project/discipline activities	⌖ Contractor /Organisation	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders
Competency	⌖ Competency of the teams/team members who formulate the start-up plan	⌖ Contractor /Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders
Team /individual participation	⌖ Encouragement the individual or dependent discipline work groups receive from the organisation or project for participation in the formulation of a start-up plan	⌖ Contractor or Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders
Best practices	⌖ Start-up plans alignment for the projects executed or being executed ⌖ Cost/Schedule goals achieved based on current best practices	⌖ Contractor or Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders

Table 9.2: Metrics for Front End Planning/Start-Up Plan

9.4.3 Project Execution

During the project execution phase of an EPC contract, the focus shifts from what was said, negotiated, agreed upon during the award of contract and planning to actions like monitoring, participating, controlling, updating and analyzing. The main functions of the project manager and his team are

- To continuously monitor the project activities and keep track on the deviation of actual performance to planned baseline performance
- To optimize trade-off's
- To track engineering milestones with an eye on procurement and construction start dates
- To monitor the change management process to accommodate changes to scope, specifications, technical queries
- To communicate the project status with the all the team members through meeting or emails
- To review completed activities
- To identify the potential sources of risk and take proactive actions to mitigate risk and hence establish contingency plans
- To continuously monitor time and quality
- To continuously update the budget and variances in cost and schedule during the life cycle of the project
- To add/remove/reallocate resources

Figure 9.3 illustrates the integration of functions and tasks during the project execution phase

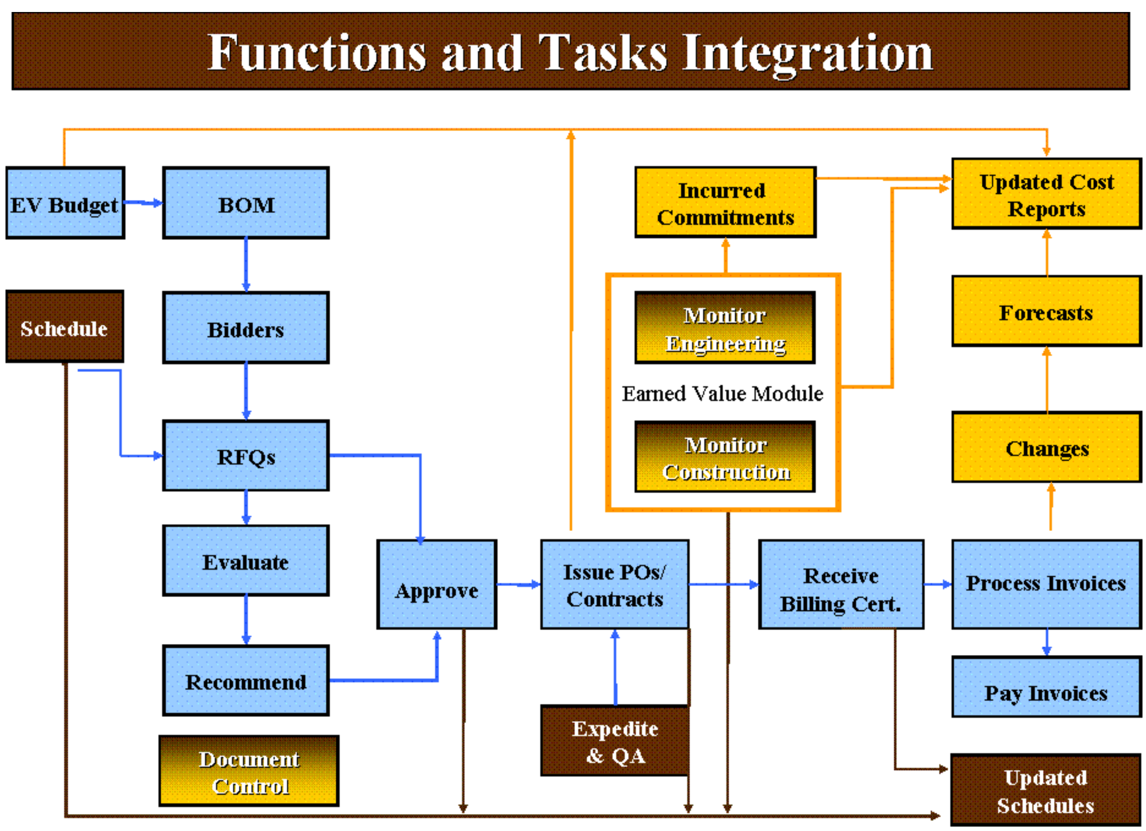


Figure 9.3: Functions and Tasks during Project Execution

(Source: http://www.ontrackengineering.com/)

The magnitude of tracking, measuring and controlling of the project activities depends on the complexity and the scale of project and therefore the success of project execution depends on the ability of the project manager to foresee challenges in advance than compensating monetarily to conform when they arise. The recorded baseline and key influencing factor metrics for the critical success factor project execution is presented in *table 9.3*.

Key Indicator	Access What?	Responsible Work Groups	Research Population
Engineering cost	⌖ Actual Engineering Cost Vs Estimated Engineering Cost	⌖ Engineering Disciplines (Process, Piping, Structural etc) ⌖ Planning Work Group ⌖ Project Management	⌖ Project Manager ⌖ Planning Work Group
Engineering schedule	⌖ Actual Engineering Schedule Vs Estimated Engineering Schedule	⌖ Engineering Disciplines ⌖ Planning Work Group ⌖ Project Management	⌖ Project Manager ⌖ Planning Work Group
Procurement cost and schedule	⌖ Actual Procurement Cost Vs Estimated Procurement Cost ⌖ Actual Procurement Schedule Vs Estimated Procurement Schedule	⌖ Planning Work Group ⌖ Project Management ⌖ Procurement Discipline ⌖ Engineering Disciplines	⌖ Project Manager ⌖ Planning Work Group
Construction cost and schedule	⌖ Actual Construction Cost Vs Estimated Construction Cost ⌖ Actual Construction Schedule Vs Estimated Construction Schedule	⌖ Planning Work Group ⌖ Project Management ⌖ Procurement Discipline ⌖ Engineering Disciplines	⌖ Project Manager ⌖ Planning Work Group
Start up resources	⌖ Mobilisation of start up resources	⌖ Project Management	⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders
Engineering discipline	⌖ Integration Between Engineering Disciplines	⌖ Organisation ⌖ Project Management	⌖ Project Manager ⌖ Engineering

integration			Discipline Leaders
Project discipline integration	⌖ Integration Between Project Disciplines (Engineering, Procurement, Construction)	⌖ Organisation ⌖ Project Management	⌖ Project Manager ⌖ Project Discipline Leaders
Engineering performance	⌖ Engineering Productivity	⌖ Engineering Disciplines	⌖ Project Manager ⌖ Engineering Discipline Leaders
Construction performance	⌖ Construction Productivity	⌖ Construction Discipline	⌖ Project Manager
Procurement performance	⌖ Procurement Productivity	⌖ Procurement Discipline	⌖ Project Manager
Timeliness	⌖ Timeliness of information from source/dependents	⌖ Project/ Engineering Disciplines	⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Table 9.3: Metrics for Project Execution

9.4.4 Information and Communication Technology

One of the key lineaments of an EPC organization is the methodology implemented to generate the information required and how the information is communicated among the seeking parties. The information sought can range from a simple verbal conversation over phone to a 3D design or 2D Drawings. The impact of information technology has seen wide spread influence on the work environment.

- Formation of new professional roles and responsibilities
- Use of automation and knowledge based systems
- Faster and enhanced coordination among colleagues (use email and telephones and work paperless).
- Outsource work to different geographical areas.
- Allowing new patterns of communication between individual and vocational groups (Virtual)
- Allowing Visualisation of the project even before it is initiated
- Usage of CAD systems such as PDMS, MICRO STATION that allow greater accuracy in design and chance for experimenting
- Formal organization and informal communication networks

- Wider participation involving all categories of professions and professionals
- Higher performance, versatile and upgraded tasks
- Possibility of achieving greater accuracy, and enhanced design of output
- Scheduling of tasks in such a way that it allows work breaks
- Allows more challenges and cross functional overlap
- More influence on the work content and pace
- Opportunity for developing creativity and imagination
- Reallocation of power in the organization
- Continuous change of structure and roles

Even though, the upshot of ICT in an EPC project environment is perceived as mentioned above, the required productivity is not yet fully appreciated. A few reasons can be that seen as the contributing factors for the negative influence of ICT on project performance are:

- Introduction of any new information system service requires high degree of preparedness for surprise, spontaneity and serendipity
- Difficult to manage the conflict between teams and systems
- Too much focus on the measurable indicators that are either qualitative or quantitative
- Too much focus on enabling the development of a new product or service or a new information system
- Requires high level of coordination and integration resulting in common goal orientation
- Avoids an opportunity to informally combine teams and technological resources to evaluate new opportunities based on common interests or concerns
- Cannot map out existing initiatives and identify the value with an ability to prioritize.
- Does not allow an organization to be open-ended in a way to accommodate change or offer resistance.
- An opportunity for cross functional product development is compromised

The recorded baseline and key influencing factors metrics for the critical success factor information and communications technology is presented in *table 9.4*.

Key Indicator	Access What?	Responsible Work Groups	Research Population
Progress monitoring	⌖ Efficiency of progress monitoring applications	⌖ ICT Discipline	⌖ Project Manager
Communication technology	⌖ Utilisation of communication technology among the disciplines/departments/team members	⌖ ICT Discipline ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline

		Members	Leaders ⌖ Discipline Team Members
Flexibility and complexity	⌖ Adaptability and responsiveness to changes in ICT ⌖ Complexity of ICT	⌖ ICT Discipline ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Information repository	⌖ Efficiency of the tools/applications/process used as common information repository in the project	⌖ ICT Discipline	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Alignment	⌖ Alignment of Information and communication tools/applications with project goals and organisation goals	⌖ ICT Discipline	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Integration	⌖ Communication between IT applications	⌖ ICT Discipline	⌖ Project Manager ⌖ Planning Work Group ⌖ Project

			Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Table 9.4: Metrics for Information and Communications Technology

9.4.5 Quality Control Practices/Best Practices

Quality is one of the decisive critical factors in the success of a project and is often regarded as accomplishing the expectations of the project participants against a standard or code or practice or procedure. Practicing quality during the execution of the project is important artillery to mitigate or control risk on a project. However, quality, as wrongly perceived is by no means minimizing expenditure. Many organizations that centre on reducing the engineering costs often indulge in unplanned activity iterations leading to delays and lower quality. Generally, it is the responsibility of the functional personnel like engineering discipline leads and checker's to ensure whether the deliverables are in accordance to the technical quality and standard procedures. A deliverable not according to the quality standards will consume substantial expenditure towards rectifying the defects in construction and maintenance work. The design and construction phases of a project are regarded as critical when it comes to the affect of quality but as a rule, the quality culture has to be imbibed across all the phases and by all the disciplines.

Quality failures in construction have been estimated to cost the industry between 2 and 12% of construction turnover in rework alone. It is estimated that the cost of design deviation accounts for 9.5% of total project cost, while construction deviation accounts for 2.5% (Memon, Abro and Mugheri, 2011) of the project cost. The focus of a contractor is to execute the project within the cost as budgeted, on or before the schedule as planned, and within the quality umbrella as defined by the codes and standards. According to the widespread opinion that the EPC project delays are almost obvious, it is the quality that is compromised to achieve the project success. But the resultant deviation with respect to cost, scheduling can be traced to a faulty design and poor constructability. In a typical EPC project the cost of project accounts for 15% of the total project cost while the construction accounts for 40% of the overall project cost. As a result, Organizations tend to shift their focus on the factors influencing construction costs but fail to understand that design is the critical factor to be focused upon. A robust quality control and management during the design process can not only reduce the engineering man hours significantly but also help construction to avoid any rework and reduce construction hours. The recorded baseline and key influencing factors metrics for the critical success factor Front End Planning/start-up plan is presented in *table 9.5*. The term best practices and quality control practices have been used interchangeably in this research.

Key Indicator	Access What?	Responsible Work Groups	Research Population
Cost/schedule escalation (engineering disciplines/procurement and construction)	⌖ Cost and Schedule Escalation with present best practices	⌖ Organisation ⌖ Planning Work Group ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline

			Leaders ⌖ Engineering Discipline Leaders
Process efficiency	⌖ Process or procedure or a system used by your project/discipline to retain/use the best practices in project execution ⌖ Alignment to developments in technology ⌖ Alignment to client requirements	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Flexibility	⌖ Adapt new or revised best practices	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Robustness	⌖ Robustness of interdisciplinary and disciplinary best practices ⌖ Consistency of product or service delivered	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Information	⌖ Quality of information from the originator	⌖ Planning Work Group ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Responsibility and expectations	⌖ Best Practices defining scope of responsibility and expectations	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Participation	⌖ Participation of individuals and teams to formulate best practices ⌖ Dedicated Team to identify and implement best practices	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Review	⌖ Frequency of review ⌖ Deliverable quality reviews/checks	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Rework	⌖ Engineering and Construction Rework due to the quality of best practices	⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager
Planning	⌖ Affect on quality due to stringent delivery times	⌖ Planning Work Group ⌖ Project Management	⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Benefits	⌖ Benefits realised on project cost, schedule and quality based on current best practices	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Table 9.5: Metrics for Quality Control/Best Practices

9.4.6 Benchmarking

The concept of Benchmarking came into existence as early as in the 1980's and has been used at Xerox Corporation to take measures owing to its reduced market share and heavy competition. The concept has later been adapted by the manufacturing industries to measure the quality of their finished product .Due to its success in achieving the requisite objective from the quality perspective; the concept has landed in the hands of management professionals who extended it to businesses and processes. Benchmarking as defined by Camp (1989) is '*the search for industry best practices that lead to superior performance*'. Construction Industry Institute (1996), defines benchmarking '*as a systematic process of measuring one's performance against results from recognized leaders for the purpose of determining best practices that leads to superior performance when adapted and implemented*'. The definition by Camp is more related to product based manufacturing industries and the definition from Construction Industry Institute, has no mention about the processes. Also the definitions do not emphasize on measuring within the organization that execute concurrent projects. IMEC (1995) defines benchmarking as '*The activity of comparing context, processes, strategies and outputs across firms/projects in order to identify the best practices and to evaluate one's position with respect to them'*. The definition provided by IMEC focuses on the processes, projects within the organization but ignores identifying and implementing improvements. Hence, the following definition based on IMEC and Construction Industry Institute has been derived and will be adapted in this research.

Benchmarking is defined as 'The organization's activity of comparing context, processes, strategies and outputs across firms and within concurrent internal projects in order to evaluate one's position with respect to other firms/projects to identify, adapt, and implement the best practices'.

According to Andersen and Pettersen (1996), benchmarking can be divided into two broad categories:

Compare What?

- *Performance Benchmarking*: Compares financial and operational performance measures with competitors
- *Process Benchmarking*: Compares of methods and practices to improve one's own processes.
- *Strategic Benchmarking*: Compares strategic choices and dispositions to improve one's own strategic planning and positioning

Compare Against Whom?

- *Internal Benchmarking*: Comparison between departments, disciplines within the same organization.
- *Competitive Benchmarking*: Direct comparison with best real competitors who deliver the same service
- *Functional Benchmarking*: Comparison of processes or functions against non-competitor companies within the same industry or technological area.
- *Generic Benchmarking*: Comparison of own processes against the best processes within or outside the industry.

As the focal point is limited to only the research unit, the benchmarking type's process, functional and generic have been adapted in this research. The recorded baseline and key influencing factors metrics for the critical success factor benchmarking is presented in *table 9.6*.

Key Indicator	Access What?	Responsible Work Groups	Research Population
Bench marking (across firms or within projects) (compare context, processes, strategies and outputs within concurrent projects /internal disciplines)	• Benchmarking process efficiency • Quality of Benchmarking • Frequency of Benchmarking	• Contractor /Organisation • Planning Work Group • Project Management • Project/ Engineering Disciplines	• Project Manager • Project Discipline Leaders • Engineering Discipline Leaders • Planning Work Group

Table 9.6: Metrics for Benchmarking

9.4.7 Lessons Learned/Knowledge Management

'A little knowledge that acts is worth infinitely more than much knowledge that is idle'.

Khalil Gibran

The terms Skill Rule and Knowledge (SRK) based performance or behaviours define the degree of conscious control exercised by the individual over his activities. The three categories essentially describe the possible ways in which information from a human-machine interface is extracted and understood (Rasmussen, 1987).

9.4.7.1 Skill Based Behaviour

This behaviour represents actions that require minimum or no conscious control once an intention is formed and is characterized by smooth and highly integrated patterns of performance. Much of the behaviour is not available to conscious thought and is automated. This behaviour requires a multitude of routine tasks in critical situations. This behaviour comes with an error potential in situations if an individual doesn't posses the skill or applies them wrongly.

9.4.7.2 Rule Based Behaviour

In this pattern the behaviour is a conscious activity characterized by the use of rules and procedures as specified by the training manuals and historical experiences in a familiar work situation. The level of conscious control is intermediate between that of skill based and knowledge based behaviour. This behaviour is situation centric and hence the expected actions are not automated following an 'if-then logic'. Potential errors related to this behaviour are diagnosis of the problem, response time, time for action and wrong actions.

9.4.7.3 Knowledge Based Behaviour

This mode of behaviour is exhibited for tasks that are new, unfamiliar or unique. This pattern is characterized by advanced level of reasoning, problem solving and successful management. The level of conscious control is very high during this behaviour. Because many critical situations unfold without any warning, the surprise effect is significant.

The SRK framework best portrays the significance of cognizance as it leads to solutions that are not a part of individual/function/organization skill set and also not a part of usual practice/process. Knowledge management is a process of capturing, recording, transferring and implementing solutions that evolve as a result of high level of reasoning and problem solving. The knowledge retained as a result can be framed into a rule and with appropriate training aids can be imparted to individuals to enhance their skills. Successful knowledge management increase the core competencies of the organization thereby generating greater value to the clients and in the process become unique to the competitors.

The recorded baseline and key influencing factors metrics for the critical success factor Knowledge Management is presented in *table 9.7*. The terms Knowledge Management and Lessons Learned are used interchangeably in this research.

Key Indicator	Access What?	Responsible Work Groups	Research Population
Culture	⌖ Organisation Support and Encouragement ⌖ Frequency of identifying, implementing and using the lessons learned in project execution	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Team	⌖ Dedicated team to identify and implement lessons learned	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Process	⌖ Efficiency of tools or process available to register and transfer lessons learned into action	⌖ Organisation ⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members ⌖ ICT Discipline	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Table 9.7: Metrics for Lessons Learned/Knowledge Management

9.4.8 Project Organisation

The goal of every organization irrespective of the sector or industry is to achieve an optimized performance using its tangible and intangible assets. The assets primarily consist of work force, their interaction on each other (team structures), their interaction with the tools and technology available in house and the interaction between the tools and technology itself. In order to optimize the organizational performance it is necessary that all aforementioned resources of the organization go 'Hand in Hand' in a manner that they are interrelated and integrated for a common goal. It is this very interconnectedness or integration of resources with the goals and motives of the organization that defines the framework of merging both teams and technology in an organization. The whole definition of macro ergonomics is about optimizing the structure and the related work systems. Owing to the participation of different partner companies (execution of a project by more than one company), management of time and budget becomes extremely complicated and challenging due the fact that people are not cognizant of one' another's behavioral traits and also ignorant of the guidelines to be followed. With shortened span of time to execute project activities, it is difficult to build mutual trust and relationships. . In such cases a temporary organization could be a potential solution. However, a temporary organization is not a solution either but on the contrary is a source of complexity. In a temporary organization, the work force involved will remain alien and hence cannot reap the benefit of common platform of learning from experience. An important activity of project learning based on the experience and reference from the previously executed projects is often missed out. A feed-back based on the project experiences should often form a feed forward for the forthcoming future projects. The recorded baseline and key influencing factors metrics for the critical success factor project organization is presented in *table 9.8.*

Key Indicator	Access What?	Responsible Work Groups	Research Population
Complexity	⌖ Difficulty in finding people to gather information	⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Trust and relationship	⌖ Relationship/trust between teams/team members	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Competency	⌖ Skills of team members/team leaders	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Project Manager ⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Opportunity	⌖ Encouragement and support to enhance skills	⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

			⌖
Productivity	⌖ Unproductive hours due to lack of information	⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members ⌖
Flexibility	⌖ Flexibility of team leaders	⌖ Organisation ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Interest	⌖ Individual interest alignment to project and organisation goal	⌖ Organisation ⌖ Project Management ⌖ Project/ Engineering Disciplines	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members
Feedback	⌖ Feedback on the quality of information provided ⌖ Feedback on the quality of information received	⌖ Planning Work Group ⌖ Project Management ⌖ Project/ Engineering Disciplines ⌖ Discipline Team Members	⌖ Planning Work Group ⌖ Project Discipline Leaders ⌖ Engineering Discipline Leaders ⌖ Discipline Team Members

Table 9.8: Metrics for Project Organisation

10 RESEARCH METHODOLOGY

10.1 Research Population

The research population is divided into three broad categories as Project Team Members Group, Project Team Leaders Group and Project Managers Group. All the employees who exert supervision on more than one individual are categorized as Team Leader Group and all the employees working at the lowest project hierarchical level are categorized as Team Member Group. As the name suggests, the project manager who has the overall responsibility of the project objectives is categorized under Project Manager Group.

10.2 Research Questionnaire

A research questionnaire has been designed based the critical success factors discussed in *chapter 9* that govern the organization success and measure the degree of integration and coordination. The baseline metrics and key influencing factor metrics that are identified in *chapter 9* for each of the critical success factors have been narrowed to a critical few and re-defined. The process of designing the questionnaire took more than the estimated amount of time and required significant brainstorming and effort. The process of designing the questionnaire required significant brainstorming and effort which translated into additional time for the process. Meetings with my supervisors and senior members of the organisation helped the researcher to narrow down the number of questions to a significant/logical few and also re-phrase the questions to remove any ambiguity.

The following guidelines and key concepts have been taken into consideration whilst developing the questionnaire.

- Accommodate all the possible answers or scenarios
- The choices of answers have to be mutually exclusive from each other
- Provide variations in the choices of answers to avoid any uncertainty of the responses
- Group the questions under a common topic/subject or theme to allow smooth transition and flow
- Provide a definition adapted for key terminologies
- Give examples where there is a chance of misunderstanding the terminology
- Design questions and choices from the eye of the target population
- Avoid branching of questions (referencing to another question) and present all questions independently
- Ranking of the answer choices have to be avoided
- The multiple choice selection has been limited to five
- Do not assume or presume current status as the responses henceforth can lead to unwarranted and unjustified assumption
- The choice of answers should not be limited to researchers required set of responses

10.3 Contents of the Research Questionnaire

Depending on the position/role of the target population in the project organization, three contrastive types of questionnaire has been designed and developed. The target population has been grouped into three main categories namely *'Team Member' (TM)*, *'Team Leader' (TL)* and *'Project Manager' (PM)*. The contents of all the three questionnaires start with two common sections *'Instructions'* and *'Employee Details'*. The instructions section includes all the necessary guidelines to be followed for answering along with details about the confidentiality, response dead line, handling and delivery of responses and the researchers contact details for clarifications.

To maximize the number of responses and attract good quality of the target population opinion, the population under research were instructed to answer the questionnaire anonymously. However, due to researchers dependency on details such as the number of projects handled or been a part of, number of years of experience and the discipline they work for etc. have been asked to publish under the section *'Employee Details'*.

The main questionnaire following the employee details section has been divided into seven sections depending on their relevancy to the subject title. The sections and questions henceforth have been divided, grouped and fragmented across the three main categories of work groups depending upon the position or role of the target population in the project organization chart as shown in *table 10.1*.

Section Number	Section Title	PM	TL	TM	Number of Questions		
					PM	TL	TM
2	Project Scope	√	√	X	5	1	0
3	Project Start-Up Plan	√	√	X	6	5	0
4	Project Execution	√	√	√	13	7	3
5	Best practices	√	√	√	22	27	27
6	Information and Communication Technology	√	√	√	6	7	7
7	Project Organization	√	√	√	7	12	12
8	Knowledge Management	√	√	√	7	7	7
9	Benchmarking	√	√	X	4	4	0

Table 10.1: Categorisation of Research Questionnaire

10.4 Measurement Scaling and Scoring

To measure the hankered variables of interest (qualitative and quantitative variables), it is necessary to categorize and quantify according to their characteristics and properties. The kind of measuring scale enforced for the collection of variables dictates the type of statistical inference test to be used for the analysis of the data. The success of variables measurement solely depends upon how well they can be measured and how much information is provided by the choice of measurement scale. An error in measurement is inevitable and therefore the amount of measurement deviation from the original decides the amount of information to be collected and the type of measurement scale.

A combination of two broad categories of data collection methods namely quantitative and qualitative has been used by the researcher in the questionnaire to gather information. While qualitative method involves in capturing information that is not measurable on a scale (numerical), quantitative method involves in collection of data that can be quantified by units or on a numerical scale. The scale of measurement helps determine the type of statistical analysis to be applied on the analysis of data for further interpretation of the data. Most of the measuring scales can be grouped under properties of mathematics magnitude and/or an equal interval between adjacent units and/or an absolute zero and non-mathematical as identity. Depending on the number of mathematical attributes the data possesses, the scales/levels of measurement are classified into four as shown in *Table 10.2*.

10.4.1 Nominal Scale

A nominal scale is the lowest grade of measurement and is used to measure categorical or qualitative variables. In a nominal scale the variables do not possess the mathematical attributes such as magnitude, equal interval, absolute zero. The variables can therefore be categorized distinctively and cannot be quantified or ranked.

10.4.2 Ordinal Scale

An ordinal scale is a higher grade of measurement than nominal scale and allows variables to be ranked in comparison with other objects. In other words, the measurement tells which object has more or less characteristics of measure (example: better than, less than, equal to etc) but does not tell by how much magnitude. The Ordinal scale does not possess the property of equal intervals or absolute zero point but has the magnitude property at a low level.

10.4.3 Interval Scale

As the name suggests, the interval scales possess the property of equal intervals between adjacent units in addition to the magnitude property. However, the interval scale lacks the absolute zero point property. This means that the measurement tells about the ranking order and the magnitude based on equal differences between the numbers on the scale. The measurement of magnitude depends upon equal amounts of variables measured between equal adjacent units on the scale.

10.4.4 Ratio Scale

With all the properties of mathematics, the ratio scale is the highest grade of measurement. With the presence of a true absolute zero point property, the ratio scale measurement allows to represent any complete absence of a characteristic of data. The ratio scale allows all the mathematical operations such as addition, subtraction, multiplication and division (Pagano, 2004).

Scale of Measurement	**Property**	**Mathematical operations**	**Descriptive Statistics**	**Inferential Statistics**
Nominal	⌖ Identity ⌖ Magnitude	⌖ Count	⌖ Mode	⌖ Non-Parametric ⌖ Chi-Square
Ordinal	⌖ Identity ⌖ Magnitude	⌖ Rank Order	⌖ Mode ⌖ Median ⌖ Range Statistics	⌖ Non-Parametric ⌖ Mann-Whitney U ⌖ Kruskal-Wallis H ⌖ Spearman Correlation ⌖ ANOVA (Friedman)

Interval	⌖ Identity ⌖ Magnitude ⌖ Equal Interval	⌖ Addition ⌖ Subtraction	⌖ Mode ⌖ Median ⌖ Range Statistics ⌖ Mean ⌖ Variance ⌖ Standard Deviation	⌖ Parametric ⌖ T-Test ⌖ ANOVA ⌖ Pearson Correlation
Ratio	⌖ Identity ⌖ Magnitude ⌖ Treated as Equal Interval	⌖ Addition ⌖ Subtraction ⌖ Multiplication ⌖ Division	⌖ Mode ⌖ Median ⌖ Range Statistics ⌖ Mean ⌖ Variance ⌖ Standard Deviation	⌖ Parametric ⌖ T-Test ⌖ ANOVA ⌖ Pearson Correlation

Table 10.2: Characteristics of Scales of Measurement

A single element equal interval 5 point scale has been used for most of the quantitative variables with nouns such as effectiveness, alignment etc. and a 10 point interval scale is used for responses to quantitative variables with nouns such as efficiency etc. For consistency of results and to ease the administration of the responses, the data has been translated to an equal interval score ranging from zero to hundred as shown in *table 10.3* for a 5-point interval scale and *table 10.4* for 10-point interval scale.

Scaled Weight in Questionnaire	1	2	3	4	5
Translated Weight	20	40	60	80	100

Table 10.3: Translated Weight of 5-Point Scale Scoring

Scaled Weight in Questionnaire	1	2	3	4	5	6	7	8	9	10
Translated Weight	10	20	30	40	50	60	70	80	90	100

Table 10.4: Translated Weight of 10-Point Scale Scoring

To ensure that the respondents mark the answers with a belief that the scale used is an interval type scale, care has been taken to represent each point on the scale is represented by a unique number with an equally spaced value from others. The following additional factors have been taken into consideration while designing the scale of measurement.

- Ensure that each score along the scale is unique and represents one unit apart from its adjacent score (interval character)

- Use appropriate anchor words such as low, high, not accurate, accurate, never met, always met etc at the ends of scales

The questionnaire also included qualitative variables that were required to be measured on an ordinal scale. As opposed to interval scale the ordinal scale does not provide quantitatively a direct comparison of the objects between its intervals. Fred Kerlinger views that 'The *best procedure would seem to be to treat ordinal measurements as though they were intervals measurements, but to be constantly alert to the possibility of gross inequality of intervals'* (Emory and Cooper 1991). Ordinal and nominal data require the use of non-parametric statistical tests *(see Table 10.2)*. But the desired parametric statistical tests are more powerful as they include any necessary operations to be performed on the values of data collected. In order to make data analysis and interpretation process easy and at the same time allow the use of parametric tests on the data, the scale of the rankings has been translated into an equal interval scale by assigning a weight to each interval (Spoonley and Pearson 2004). *Table 10.5* shows the translated weights for all the qualitative variables used in the questionnaire based on the possibility of gross inequality of intervals.

Categorical Scale on Questionnaire	Translated Weight
YES/CONTINUOUSLY	100
MOST OFTEN	75
SOMETIMES YES; SOMETIMES NO/ONLY WHEN THERE IS NEED	50
OCCASIONALLY/RARELY/MAY BE	25
NEVER/DON'T KNOW/NO	0

Table 10.5: Translated Weight of Categorical Scale

In addition to the quantitative and qualitative type of questions, the researcher also introduced a few open ended and multiple option questions. These open ended questions are used to capture free responses in the respondents own words which are expected to be unique and versatile. The multiple choice questions allow the respondent to choose more than one fixed options and are intended to capture the thoughts of the respondents subjectively channelized in a defined direction.

10.5 Research Statistical Sampling

With the size of the research population being on the higher side**,** it was unmanageable to research all the target population. Hence, it became important to identify a small group of population who are representative of the total research population. Cooper and Schindler (2003:179) described sampling as the procedure by which some elements of a given population are selected as representative of the entire population. The objective of sampling is to draw conclusions about the entire population by selecting some elements of a heterogeneous population and hence determining the size of the sample was a big challenge. The selection of sampling size depends on factors such as purpose of research, total population size, allowable sample error and the risk of a bad sample. According to Miaoulis and Michener (1976), the three additional attributes: the level of precision, the level of confidence or risk and the degree of variability have to be taken into consideration when rounding of a sample size (Israel, 1992).

The level of precision or the sampling error is defined as the range expressed in percentage in which the true or actual value of the sample is estimated to be. Based on the central limit theorem, the confidence level or the risk level is the normal distribution of the response data within two standard deviations of the true responses. The confidence level accommodates the risk of extreme deviation of responses from the sample that do not represent the true value. The degree of variability is the distribution of attributes in a heterogeneous population depending upon the required precision of the true value.

10.5.1 Sample Size

Israel (1992), defines four different strategies that can be used to determine the sample size: by using a census for small populations, by using a sample size of a similar research, by using published tables and using formula to calculate the sample size. The use of census for small population requires a research of the total population and hence provides great level of precision eliminating sampling error. But such an approach is limited to only small populations. With no sample size of a similar study available and absence of researcher's criteria in the published tables, the research adopted two equations developed by Cochran (1963:75) as shown below to calculate the required sample size.

$\mathbf{n_0 = Z^2pq/ (e^2)}$ ----- Equation for calculating a sample for proportions -- Equation (1)

Where:

$\mathbf{n_0}$ = The Sample Size

Z = abscissa of the normal curve that cuts off an area at the tails (1 - equals the desired confidence level). The desired confidence level used by the researcher is 95% and hence the corresponding value of Z from the statistical table is 1.62

p = estimated proportion of an attribute that is present in the population = 0.90

q = complement of p (1- p) = 0.01

e = Level of precision = ± 10 %

$\mathbf{n = n_0/ (1+ ((n_0 - 1) / N))}$ ----- Finite population correction for proportions- Equation (2)

Where:

n = Reduced Sample Size

N = Total Population = 400

Using Equation (1) and Equation (2), the calculated sample size has to be a minimum of 12.58 i.e. 13.

10.6 Gathering Responses

A research background letter was used to explain the description of the dissertation, the objective and goal of the questionnaire to motivate the respondents. Two separate questionnaires: one for the Team Lead and other for the Team Member has been emailed to all the department managers of the contractor for electronic distribution. The questionnaire to the project managers has been handed over personally. In addition to the questionnaires a covering letter and a short background stating the objective of the research and the goal of the survey has been included. The covering letter was drafted after recording the minutes of meeting with the top management of the contractor and includes instructions that require the respondent's adherence to privacy and confidentiality. The draft also indicated that the responses will/would not be used for any other purpose except for the research and the collected data and analysis henceforth will be kept in strict confidence.

With a requirement for adherence to maintain privacy and confidentiality from the contractor, the survey population has been asked to mark all the responses on a printed paper. The responses have been asked to be dropped in a box that was made available at the reception office. Clarifications required by the target population have been adverted to through email, phone and personal visits to their offices.

Considering the busy on-going project execution activities, the researcher received better than the required minimum responses. In order to accommodate all the 22 responses, the researcher back calculated the precision level with the new sample size n = 22 using equation 1 and equation 2 for finding the sampling size and decreased the level of precision to ± 7.7 %. The responses have been checked for ambiguities such as missing data, double entries and found to be almost accurate to the desired expectations of the researcher.

10.7 Data Entry and Coding

After the preliminary checking of responses, all the data has been transferred manually to Microsoft Excel '97 application and has given the researcher a second opportunity to verify any ambiguities. As shown in *table 10.6*, the transfer of information followed the same sequence as published in the questionnaire which consists of 9 combined main sections namely Respondent Profile, Project Scope, project Start-Up Plan etc. with a corresponding incremental positive integer starting from 1 to 9. All the subsequent questions belonging to each section follow an incremental addition to the section number with a rational number of the order 0.1.

The most common conceptual framework adopted in a quantitative research and analysis is to investigate the relationship among the measured variables. Such a framework defines the relationship among the variables that can be manipulated and the observations that are eventually affected. According to Sekaran (2003), the independent variable is the cause that influences the dependent variable, or the effect, in either positively or negatively.

An *independent variable* also referred to as *'controlled variable'*, *'manipulated variable'* or *'input variable'* are the variables that can be manipulated by the researcher and the effects of which are to be measured or compared. While in an experimental research, the independent variable can be manipulated or controlled to observe the level of affect on the dependent variable, the non-experimental research can only logically connect the independent variable to dependent variable without manipulation (Kerlinger, 1986).

When an independent variable cannot be controlled or manipulated, the variable is termed as status variable. However, Heppner, Kivlighan and Wampold (1999), suggest that the status variables can be used by the researcher to manipulate according to the needs, treating them as independent variable.

The *dependent variable* also termed as *'measured variable'*, *'observed variable'*, *'output variable'* or *'explained variable'* are variables that are quantified or observed for their effect as a result of independent variables. The dependent variable is not manipulated in a research and is gauged for its variation as a presumed result of variation in one or many independent variables.

The research trifurcated the measurements into 55 independent variables, 14 dependent variables (based on the description of critical success factors in *chapter 8*) and 11 status variables. With an implicit objective of the research being to quantify the responses, the researcher used codes to identify independent, status and dependent variables with respect to each section of the questionnaire. To enable quick identification the rows with independent variables are marked with colour orange, dependent variable with colour yellow and status variables with colour cyan as shown in *table 10.6.* For ease of presentation, further interpretation and eventual analysis, a code has been assigned to each variable. The code used is a combination of a special character '@', followed by a short code depending upon the categorical type of the variable type (I -Independent Variable, D - Dependent Variable, S - Status Variable), short code of critical success factor or section heading (RP - Respondent Profile, PS - Project Scope, SP- Project Start-Up Plan, PE - Project Execution, BP - Best Practices, ICT - Information and Communications Technology, PM - Project Organization, KM - Knowledge Management, BM - Benchmarking) and a sequential incremental positive integer starting from 1 to number of questions in a section as shown under the column 'Variable Code' in *table 10.6.* The variables are mapped against the five components of integration and are coded as 'V' for vertical component of integration, 'H' for horizontal component of integration, 'L' for longitudinal component of integration, 'C' for organisational human ware coordination and 'T' for technical coordination.

Seq. No	Metric/Question	Component of Integration and Coordination	Variable Code
1	**Respondent Profile**	**NA**	**NA**
1.1	Discipline/Specialisation	NA	@1SRP1
1.2	Years of service in the present organisation	NA	@1SRP2
1.3	Number of projects involved in the present organisation	NA	@1SRP3
1.4	Role in the Organisation	NA	@1SRP4
2	**Project Scope**	**NA**	**NA**
2.1	Level of project complexity with respect to the competency of the Organisation for the projects being executed	NA	@2SPS1
2.2	Percentage of contracts of type 'Lump Sum' being executed or have been executed by the organisation	NA	@2SPS2
2.3	Percentage of contracts of type 'Unit rate or Unit Price' being executed or have been executed by the organisation	NA	@2SPS3
2.4	Percentage of contracts of type 'Cost Reimbursable Or Cost Plus' being executed or have been executed by the organisation	NA	@2SPS4
2.5	Percentage of contracts of type 'Target Price' being executed or have been executed by the organisation	NA	@2SPS5
3	**Project Start-Up Plan**	**NA**	**NA**
3.1	Availability of organisation policies/procedures that govern the budget/schedule estimates for the project execution activities	V/C	@3SSP1
3.2	Accuracy of policies governing budget/schedule estimates	V/C	@3ISP2
3.3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates	V/C	@3DSP3
3.4	Encouragement from Organisation for Start-up Plan formulation	V/C	@3ISP4
3.5	Competency of the teams/team members who formulate the start-up plan	V	@3ISP5
3.6	Level of Start-Up Plan alignment for the projects executed or being executed	V/C	@3ISP6
4	**Project Execution**	**NA**	**NA**
4.1	Mobilisation of Start-up resources on time	V	@4IPE1
4.2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals	L	@4DPE2
4.3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job	H/V	@4DPE3
4.4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job	V	@4DPE4
4.5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job	V	@4DPE5
4.6	Level of integration between the Project disciplines (E, P and C)	V/C/T	@4IPE6
4.7	Level of integration between the engineering disciplines	H/C/T	@4IPE7

4.8	Benefits realised on project cost, schedule and quality based on existing best practices	C/T	@4DPE8
4.9	Amount of Construction rework due to inferior Engineering Quality	V/C/T	@4DPE9
4.10	Effectiveness of Information Technology applications to monitor progress made during project execution	T	@4IPE10
4.11	Incentive Schemes (if any) banked by the Projects that have been executed	L	@4DPE11
4.12	Incentive Schemes (if any) NOT banked by the Projects that have been executed	L	@4DPE12
4.13	Timeliness of the dependent disciplines for information	V/H/C/T	@4IPE13
5	**Best Practices**	**NA**	**NA**
5.1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality	V/C/T	@5DBP1
5.2	Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality	V/C/T	@5DBP2
5.3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality	V/C/T	@5DBP3
5.4	Flexibility of disciplines with respect to adapting the best practices	V/H/C/T	@5IBP4
5.5	Robustness of interdisciplinary best practices	V/H/C/T	@5IBP5
5.6	Best practices driven to satisfy client requirements	V/H/C/T	@5IBP6
5.7	Best practices driven by Developments in Technology	V/H/C/T	@5IBP7
5.8	Best practices driven by the need to improve engineering quality	V/H/C/T	@5IBP8
5.9	Best practices driven by the need to improve construction quality	V/H/C/T	@5IBP9
5.10	Best practices driven by the goal to execute work for the estimated cost and planned schedule	V/H/C/T	@5IBP10
5.11	Best practices driven by competitors	V/H/C/T	@5IBP11
5.12	Procedures/work instructions clearly defining the scope of responsibility	V/H/C/T	@5IBP12
5.13	Best practices driven by the need to maintain consistency of product/service	V/H/C/T	@5IBP13
5.14	Procedures/work instructions clearly defining the expectations of your responsibility	V/H/C/T	@5IBP14
5.15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes	V/H/C/T	@5IBP15
5.16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution	V/H/C/T	@5IBP16
5.17	Dedicated team to identify and implement the use best practices in project execution	V/H/C/T	@5IBP17
5.18	Construction rework due to a team or team member	V/H	@5DBP18
5.19	Level of on job Quality Control practices/reviews followed on the job	V/H/C/T	@5IBP19
5.20	Quality of information from dependents	V/H/C/T	@5IBP20
5.21	Timeliness of information from dependents	V/H	@5IBP21
5.22	Amount of rework as a result of incorrect or inferior quality of information from dependents	V/H/C/T	@5DBP22

5.23	Effect of planning on the quality of deliverables	V/H	@5IBP23
5.24	Feedback on the quality of information provided	C/T	@5IBP24
5.25	Feedback on the quality of information received	C/T	@5IBP25
5.26	Documentation/recording/transferring of the feedback received from dependents into a procedure/best practice	C/T	@5IBP26
5.27	Level of your participation/involvement in procedure or work process formulation	C/T	@5IBP27
6	**Information and Communications Technology**	**NA**	**NA**
6.1	Utilisation of communication technology among the disciplines/departments/team members	C/T	@6IICT1
6.2	Level of team's adaptability/responsiveness/flexibility to change in ICT	C/T	@6IICT2
6.3	Efficiency of the tools/applications/process used as common information repository in the project	C/T	@6IICT3
6.4	Level of Information and communication tools/applications alignment with project goals and organisation goals	C/T	@6IICT4
6.5	Level of complexity of ICT to receive interdependent information between/across the disciplines	C/T	@6IICT5
6.6	Level of complexity of the source for retrieving/receiving the information from dependents	C/T	@6IICT6
7	**Project Organization**	**NA**	**NA**
7.1	Level of complexity involved in finding people to gather information	C/T	@7IPM1
7.2	Level of trust on team members	C/T	@7IPM2
7.3	Level of relationship/trust on dependents	C/T	@7IPM3
7.4	Level of relationship/trust on receivers of information	C/T	@7IPM4
7.5	Level of opportunity/support from the organisation to enhance skills	C/T	@7IPM5
7.6	Level of non-productivity due to lack of information from dependents	C/T	@7IPM6
7.7	Flexibility of supervisor to new ideas or processes	C/T	@7IPM7
7.8	Competency level of supervisor	C/T	@7IPM8
7.9	Alignment of interest to organisation goal	V/H/C	@7IPM9
7.10	Organisation culture encouraging innovation	V/H/C	@7SPM10
8	**Knowledge Management**	**NA**	**NA**
8.1	Frequency of lessons leaned implementation	L/C/T	@8IKM1
8.2	Support from organisation to identify, implement and use the lessons learned program	L/C/T	@8IKM2
8.3	Frequency of Lessons learned getting converted into best practices or procedures	L/C/T	@8IKM3
8.4	Availability of dedicated team to identify and implement the lessons learned in project execution	L/C/T	@8IKM4
8.5	Culture of lessons learned process or knowledge management in the discipline/project	L/C/T	@8IKM5
8.6	Efficiency of tools to register and transfer lessons learned into action	L/C	@8IKM6
9	**Bench Marking**	**NA**	**NA**
9.1	Availability of benchmarking process	L/T	9IBM1
9.2	Frequency of utilisation of benchmarking process	L/T	9IBM2

9.3	Quality of benchmarking process	L/T	9IBM3

Table 10.6: Data Coding for Independent, Dependent and Status Variables

10.8 Univariate Statistics

Out of the three available types of descriptive univariate statistics, the researcher used the measures of central tendency and measures of variability to present the measurements. Measures of central tendency are used to present the centre and region around which the observed data is distributed using the properties mean, mode and median. To present the spread of the observed data properties of measures of variability such as range, variance, standard deviation and range is used by the researcher.

10.9 Reliability

In simple terms reliability of the observations refers to measure of consistency of observed data. Carmines and Zeller (1979) view reliability as the extent to which the observations made through a research instrument yield same observed values upon repeated trails. Unreliability of the data (deviation of the observed values upon repeated trials) cannot be avoided to a limited extent; a simple measure of tendency in the form of consistency upon repeated measurement is termed as reliability. The repeated measurement can be overtime and across situations. The definition by Carmines and Zeller (1979) measures reliability with *'consistency'* as the only dimension of measurement. However, Salkind (2000), views reliability with an additional dimension of measurement, repeatability, and defines reliability as the measure of two dimensions repeatability and internal consistency with which the research instrument measures a variable and helps to access the goodness of measure.

For measuring the repeatability, Test-Retest method dominates the feasibility and usage. Two widely used tests are available for measuring the internal consistency of the data: Split-Half Method and Cronbach-Alpha Method. The researcher used Cronbach-Alpha Method to measure the consistency of the observed data which provides the estimate of internal consistency reliability through a reliability coefficient called Cronbach-Alpha expressed as

$$\text{Cronbach-Alpha} = N/\ (N-1)\ [1-\sum\sigma^2\ (Y_i)/\ \sigma^2 x]$$

Where,

N, is the number of observations

$\sum\sigma^2\ (Y_i)$, is the sum of variance of the observations

$\sigma^2 x$, Variance of the total observations

The value of Cronbach-Alpha coefficient ranges from 0 to 1 with the degree of consistency increasing as the value tends to be closer to 1 (Zikmund, 2000). The research used SPSS v20 application to calculate the reliability coefficients for the included variables under each critical success factor.

10.10 Missing Data

Many research studies were conducted over the last three decades to investigate the pertinanceof the length of the research questionnaire on the willingness of the research population to participate and respond. The outcome of such an investigation indicated an inversely proportional relationship between the length/number of questions in a research questionnaire and, the eventual participation and response of the research population. When conducting a research, especially of a large scale, the likelihood for a research to reach its objective conclusively increases with the increase in the number of responses or the amount of data. With significant time and cost involved in administering such a research along with human factors such as level of motivation and psychology of the population, the researcher is at risk of the efficiency of the results. To satisfy the demands of conducting a research of large scale, over the last decade, researchers have developed frameworks and methodologies in the form of associative statistical tools. The use of statistical tools allows the researcher to narrow down the number of questions in the research thereby reducing the length of tests and at the same time increases statistical quality of the data with fewer numbers of observations.

10.11 Why Missing Data?

With panoptic efforts going in designing the research questionnaire, the researcher's need to cover a wide range of information yields more number of questions than planned. The bi-product of such a questionnaire is missing data leading to biased, unreliable and inefficient research conclusions. Fox (2012) states one or more of the following reasons for incomplete data in a research response.

- Refusal to participate in the research or may not be reachable
- Few respondents may not know the answers to the questions or intentionally stay neutral by not answering.
- Researcher may miss asking the question in an interview based data collection
- Researcher has intentionally designed the questionnaire such that the questions are random to a defined set of respondents

Researcher has conditionally not defined certain questions to specific groups of respondents, also known as Planned Missing Data Design. In a planned missing data design, the researcher designs the questionnaire with an intentional purpose to miss data to be gathered.

In this research, the researcher has intentionally grouped the questions into three broad categories based on the roles of the participants in the organisation following the vertical logic of a project organisation hierarchical matrix that thins down from the operational level to the management level. For example, the metric to find out the cost schedule goals achieved by the research unit has intentionally not been included in *'Team Member'* questionnaire as it will/may invite incorrect/inaccurate guessing from the operational level groups who most often are unaware of the same. The three sets of questionnaire used in this research can therefore be referred to as *'Planned Missing Data Design'* wherein the researcher intentionally designed the questionnaire in such a way the relevancy of the questions is maintained in the three user groups, participation of the population is encouraged and practice effects are accounted.

10.12 Types of Missing Data

According to Rubin (1976), missing data can be classified as one of the following three categories depending upon the underlying reason as to why the data is missing.

10.12.1 Missing Completely at Random (MCAR)

The missing data can be classified as *MCAR*, if the missingness is completely at random and incidental. In this case the simple random observed sample is assumed to postulate the non-observed sample of the whole population as a whole.

10.12.2 Missing at Random (MAR)

Contrary to what the name suggests, the MAR does not assume that the data is missing at random. In MAR, the missing data assumes that the property of missingness is a function of other observed data in the data sample collected and hence can be predicted. However, the missingness of data attended in MAR is not at random but through a dataset that has a strong relationship with the predictors.

10.12.3 Not Missing at Random (NMAR)

Also referred to as Missing Not at Random, the missing data is characterized by missing information from the research that can only be predicted through the correlation of other missing variables.

The following example by Schafer and Graham (2002), illustrates the associated rules to be followed for the categorization of the types of missing data:

Let,

'X' denotes the completely observed variable(s)

'Y' denotes partially observed variable(s)

'Z' denotes the unobserved variables or properties of the causes of missingness unrelated to 'X' or 'Y'

'R' denotes missingness or the probability of missingness

Then, in MCAR, the missing data for the partially observed variable 'Y' is totally exclusive with the remaining variables in the dataset or with the variable 'Y' itself. In other words, the missingness or the probability of missingness 'R' of partially observed variable 'Y' is not dependent on either 'X' or 'Y'. However, it can be assumed that the observed variables are a random sample representing a complete theoretical data set.

In MAR, the missing values in partially observed variable 'Y' is not associated with the unobserved variable(s) 'Z' or with variable 'Y' itself but can be associated to other variables that are measured. In probability of the partially missing variable 'Y', 'R', is dependent on the observed variable 'X'.

The missing data is NMAR, if there is a partial relationship between the observed variable 'X' and unobserved variable 'Z' with the probability that partially observed variable 'Y', 'R', having significant relationship with the underlying values of 'Y' itself.

The correction of the missing data in MAR is not possible as the researcher cannot distinguish between MAR and MNAR for the sole reason that the research requires data of all the missing data points and such a requirement demands knowledge of variables not observed or measured. However, correcting the missing values by categorising them as MCAR comes as a blessing to the researcher. The missing values under the category MCAR will allow the data to be tested and thereby included or rejected in the analysis using statistical techniques. Littvay (2009), states that, for a planned missing data design, where the data not collected (missing) are randomized by design, MCAR is a realistic assumption. With the use of a planned missing data design for this research, the researcher categorised the missing data associated to population sizes in a vertical hierarchy into MCAR.

10.13 Handling Missing data

Once the missing data is categorized based on the mechanisms followed in the missingness of information, the next step is to approximate the estimation. The requirement of such estimation has to be unbiased and at the same time follow the pattern of observed information. With MCAR missing data it is often possible to analytically correct the dataset with a realistic assumption using traditional and modern analytical tools. A few analytical tools are discussed below describing the approach used along with their applicability in providing a solution to solve missing data:

10.13.1List wise Deletion

In the list wise deletion, if a single data observation is missing, then the whole case is deleted and is used when the sample size is uniform and small. The approach is applicable only if the missing data is at least random (MAR) and produces biased estimates for MAR and MNAR. If the missing data is completely at random (MCAR) then the power of the estimate is questionable even though the results are unbiased.

10.13.2Pair wise Deletion

The approach follows the rule of deleting the cases by systematically analyzing the data observation that is missing and has a capability to produce unbiased estimates if the data is missing completely at random (MCAR). The approach does not find widespread application but can be used for a pair-wise comparison of variances.

10.13.3<u>Mean Substitution</u>

The analytical approach simply uses the mean of the observed sample for a sample wise missing observations and mean score of other observed items in the dataset for a case-wise to estimate the missing values. The issue with the approach is that the variances and correlations are biased due to attenuation of the values. As a result, the estimates either reduce the effect of observed variables with respect to missing observations or tend to exaggerate the variables with little available data.

10.13.4<u>Regression Imputation</u>

Multiple regression analysis technique is the approach used to estimate or predict the missing values in a regression imputation. The available observed data is used to calculate the regression of the missing variable using the predicted mean of each unobserved value. The regression imputation can produce unbiased estimate of means and regression coefficients than a simple mean substitution. With small variability of the estimated values, the accuracy of the calculated regression coefficients can lead to incorrect and misleading conclusions.

10.13.5 <u>Multiple Imputation</u>

A modernistic approach to attend the missing data challenges is through multiple imputation technique. The technique uses a process of creating multiple complete datasets typically of the order 5 or more to impute the missing values. By imputing multiple datasets, the uncertainty associated with the missing values is deduced from the predictive distribution of the unobserved variable. As a result the approach produces more than one complete datasets for the application of standard statistical analysis techniques.

The research used the statistical multiple imputation technique for handling the planned missing data using SPSS v20 application.

10.14<u>Factor Analysis</u>

For a research featuring a number of questions for the collection of numerous variables to characterize an object or define the relationship among variables, the administration and analysis will be complicated. Often such a questionnaire with long set of questions can be reduced to a few that can still deduce the required objective of measuring some underlying variable(s). Factor analysis is a technique of multivariate statistics that allows the researcher to reduce the data or observations to represent a wide range of variables on a smaller number of dimensions. Factor analysis is a branch of statistical multivariate technique to extract information from large databases and identify the interrelated data (Hair et al., 2008). Factor analysis technique summarizes the interrelated observations into a more general and underlying dimension that is usually missed in the examination of the raw data or sometimes the correlation matrix. The technique ignores redundancy and duplication from a set of correlated observations and compiles the results into a small set of 'derived' or 'surrogate' variables describing the concepts of original variables. Hair et al. (2008), provides following applications of factor analysis.

- Identification of the underlying dimensions by creating new variables or transforming cluster variables into homogeneous groups that can possibly explain the correlation between a set of related variables.
- Categorisation of variables that are not correlated into small groups that can replace the original set of correlated variables to enable multivariate analysis such as regression and discriminant analysis.
- Categorisation of observation or variables into small groups that are representative of the characteristics of the larger set.

The research used the seven steps proposed by Rietveld and Van Hout (1993) to perform factor analysis to reduce the number of observations into a smaller set of surrogate variables as shown in the flow diagram *figure 10.1*.

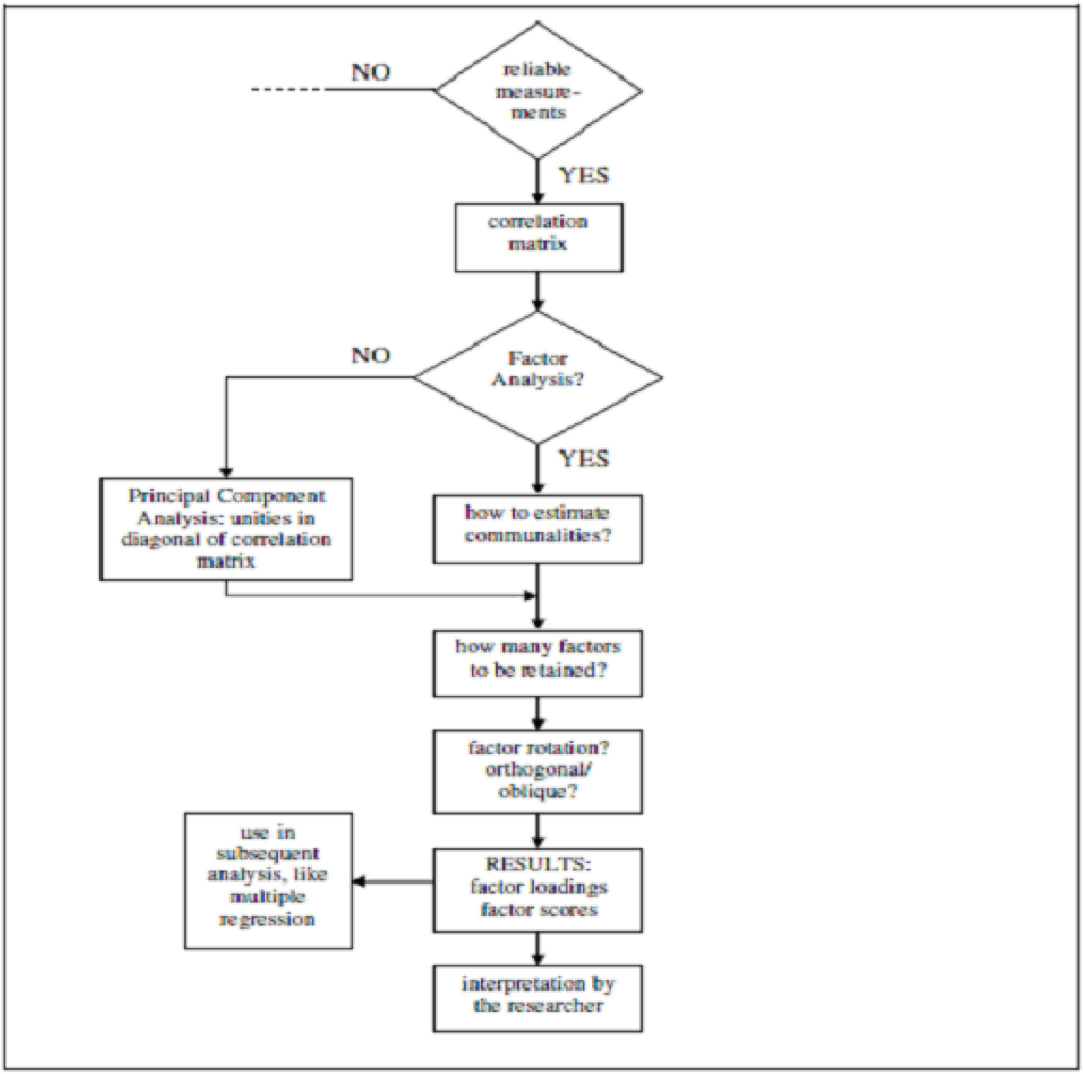


Figure 10.1: Steps in Factor Analysis

(Source: Rietveld and Van Hout, 1993, p.291)

The first step in factor analysis involving reliability measurements has been discussed in *section 10.9*. The correlation matrix is a lower triangle matrix representing the correlation between all the paired set of variables included in the analysis. The diagonal dimensions of the matrix are ignored as they denote the correlation between a pair of same variables. The correlation matrix in this research is derived using SPSS v20 application. The correlation matrix is checked for the correlation coefficient/factor among the variables to ensure that the variables are not highly correlated. To avoid extreme singularity and extreme multicollinearity that would pose difficulties to determine the unique contribution of the variables to a factor, the Bartlett's test of Sphericity is calculated using SPSS v20. The Bartlett's test of Sphericity is a statistical collinearity test to examine the hypothesis that the variables included in the test are not correlated. Such a test has to result in a Bartlett's test of overall significance to be less than 0.05 to ensure that the characteristic of multicollinearity does not exist among the included variables. The researcher used the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy to check the appropriateness of using factor analysis with an assumption that the initial communalities are not unity but are estimated by taking the squared multiple correlations of a variable with other variables. The usage of factor analysis in this research is checked by calculating Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy index using SPSS v20. The index ranges from 0 to 1 and the closer the calculated index to 1 (with a minimum of 0.6), the more is the appropriateness to proceed for the factor analysis.

An Eigen value and Scree test is used to identify the number of factors to be reduced for further analysis. An Eigen value represents the total variance explained by each factor and the research followed the Guttman-Kaiser rule which proposes to use factors with values more than or equal to 1 in order to consider a factor significant. The extraction of an optimum number of variables before the degree of variance for each included variable dominates the other is done through a Scree Test. SPSS v20 is used to calculate the Eigen value and perform the Scree test with the results of the Scree test are represented using a Scree plot and a component matrix table. The component or communalities matrix table lists out factors extracted in the order of their importance from a higher to a lower value of variance. The component matrix table is used to check for the factor loadings (correlations between variables and factors). If the variables are loading on one factor then the factor will be used as a derived or surrogate variable that represents the group of included variables in factor analysis. A Varimax factor rotation is used if the variables are loaded on more than one factor and the variable that has the maximum loading is used as surrogate variable. The research used the statistical factor analysis in SPSS v20 application to reduce the number of variables and summarize the interrelated observations into a more general and underlying dimension.

10.15 <u>Relationship among Variables</u>

One of the key objectives of any research involving in a collection of sample observations is to understand and determine the relationship or association between them. The bivariate correlation is a statistical technique dominantly used as a test to determine the relationship between any two continuous or interval or ordinal variables. Such a test yields an index referred as correlation coefficient and yields three possible outcomes ranging from -1 to +1 depending upon the direction or pattern of relationship between the variables tested. The positive correlation coefficient indicates that the relationship between the variables is positive or moves the same direction over a given period of time. A positive bivariate correlation coefficient of the order +1 indicates that the two variables are perfectly correlated. When one variable trends in an opposite or inverse direction with respect to another variable, the correlation coefficient is negative. A negative bivariate correlation coefficient -1 indicates that the two variables are perfectly not correlated. Irrespective of the coefficient being positive or negative, the strength of the relationship is indicated by the closeness to zero. The closer the coefficient to zero, the less strong is the association and vice-versa.

The Pearson's bivariate correlation coefficient has been used in this research to determine the association between the observed measurements. In order to check whether the relationship is statistically significant or not, a 2-tailed test has been adapted. The research used a significance level of 0.05, to ensure that the researcher is 95 % confident about the estimating the population.

10.16 <u>Regression Analysis</u>

The use of Pearson's bivariate correlation helps to understand the relationship between variables but does not provide the effect of one variable on the other. Regression Analysis is a statistical technique that calculates the nature of relationship between the dependent and the independent variable. In other words, the regression analysis yields a regression coefficient that indicates the measure of change in the independent variables (cause) associated with a change in dependent variable (effect). The more the regression coefficient (slope of the regression line), the more is the change or influence and vice-versa. The research adapted both single factor (with one independent variable) and multifactor (more than one independent variable) regression models to quantify the relationship. The frequently used linear regression model is adapted in this research and is represented by the following equation.

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots .. + \beta_i X_i + e_i$$

Where, Y = Dependent Variable
A = Intercept
β_i = Beta values for X_i
X_i = Independent Variable

$e_i =$ Error Value
(Coakes and Steed, 2007)

10.17 ***Hypothesis Testing***

Hypothesis testing also referred to as conformatory data analysis is a statistical concept in statistics that addresses the associated uncertainty in a sample estimate. Hypothesis testing technique is also used to determine if a variable can predict another variable, if or not one group differs from the other, if or not one variable affects another variable. Churchill (1995) defines hypothesis as a '*statement that specifies how two or more measureable variables are related'*. The statement is specified in terms to two elements of a hypothesis test: a null hypothesis and an alternative hypothesis. While a statement stating null hypothesis is accepted if there is no association between the dependent and independent variable, a statement stating alternative hypothesis is accepted if the result is contradictory to null hypothesis. However, the results of a hypothesis test yields 2 types of errors. Type-I error occurs when a true null hypothesis is rejected and a Type-II error occurs when an incorrect null hypothesis is accepted. The p-value is used to indicate the Type-I error in statistical analysis and presents the probability of rejecting the null hypothesis when it is actually true. In other words, if the test yields a p-value less than the significance level used in this research i.e. 5 % ($p<0.05$), then it can concluded that the unlikely to be true. If the p-value is more than 0.05, then the null hypothesis statement is accepted and rejected if otherwise. The p-value is used in this research for evaluating the results of hypothesis testing on whether a certain explanatory independent variable can predict or explain the dependent variable. The research shall use hypothesis statements to test if the independent variables collected are sufficient to determine their effect on dependent variables.

11 Descriptive Statistics

Chapter 10 explained the detailed research methodology applied in gathering and recording methodology used for the responses from the research unit personnel. In this chapter the responses gathered from the questionnaires will be presented using tables, graphs and pie-charts as descriptive statistics. Statistical tools will be used for the analysis of the data.

11.1 Profile of the Research Sample Population (RP)

The first section of the questionnaire consists of questions to identify the characteristics profile of the respondents in the research unit. The purpose of the section is to check whether the demographic characteristics i.e. role in the research unit, area of specialization, experience in the research unit and number of projects the respondent was involved of all the horizontal, vertical work groups are participating in the research. Identifying the profile of the respondents also provides the spread of their attributes against a pre-defined categorical classification.

11.1.1 Role or Designation (@1SRP1)

The profile of the research sample population with respect to their current role or designation in the research unit is summarized in the *table 11.1*.

Characteristics	Classification	Samples	Research Percentage
Role	Project Manager	3	13.6 %
	Team Lead	8	36.36 %
	Team Member	11	50 %
		Total = 22	100 %

Table 11.1: Role Characteristics of Research Sample Population

Comment: As discussed in the *chapter 10*, the questionnaire is grouped under three major categories *'Project Manager', 'Team Lead/Discipline Lead', 'Team Member'*. The relevancy of research questions has been maintained in accordance to the current roles of the research sample population in the project organization. The number of responses from the research sample population followed the vertical logic of a project organization hierarchical matrix thinning down from the operational level to the management level. 50 % of the response population belonged to the operational hierarchical level and 36 % of the response population belonged to the middle management level responsible for monitoring the goals of their respective specialized discipline team. Out of 4 active project managers, the researcher received 3 responses contributing to 13% of the overall research sample. The percentage distribution of research sample population based on their roles in the research unit is graphically shown in *figure 11.1* using a pie-chart.

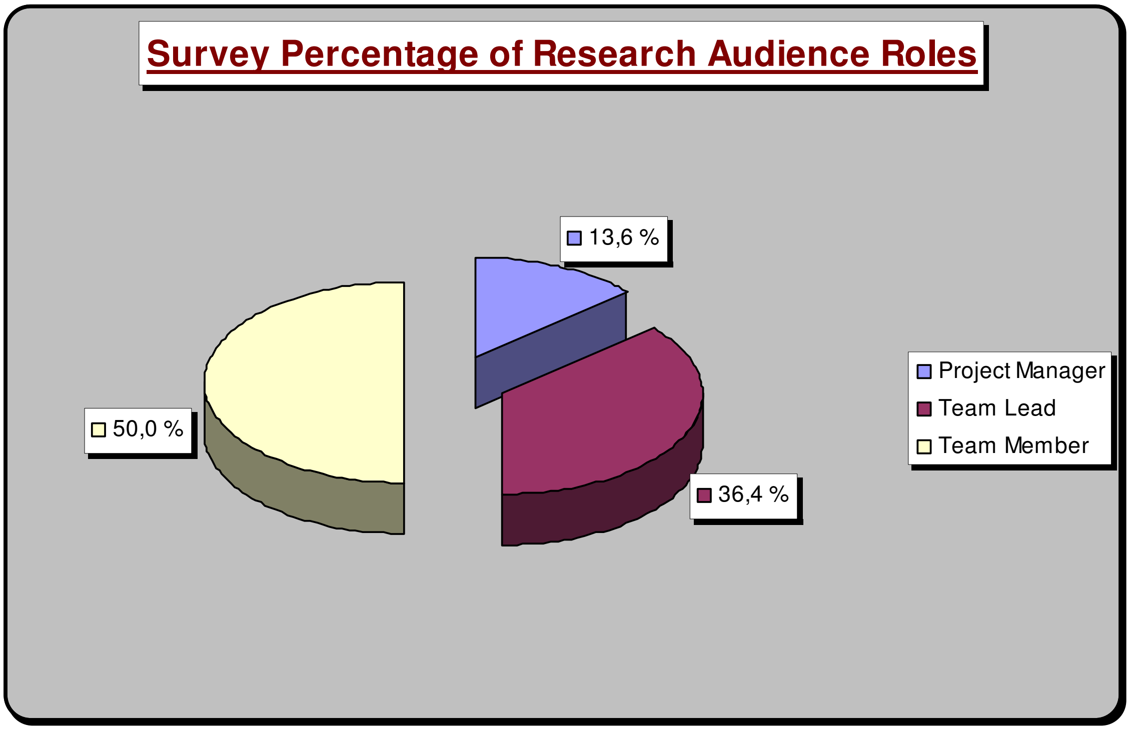


Figure 11.1: Percentage Split of Research Sample Population Roles

11.1.2 Work Group or Specialisation (@1SRP4)

The profile of the research sample population with respect to their specialization in the research unit is summarized in the *table 11.2*.

Characteristics	Classification	Samples	Research Percentage
Work Group	Project Management	3	13.6 %
	Planning	1	4.5 %
	Process	5	22.7 %
	Piping	5	22.7 %
	Structural	3	13.6 %
	Mechanical	1	4.5 %
	Electrical and Instrumentation	4	18.1 %
		Total = 22	100 %

Table 11.2: Specialisation Characteristics of Research Sample Population

Comment: Out of 22 responses from the research sample population, 18 responses are from the horizontal groups of engineering. In a typical E-P-C project the weighted value apportioned to the horizontal engineering work groups by a ratio of engineering man-hours in terms of percentage is 22.5 % for piping, 8 % for process (including HSE), 5.4 % for mechanical (for both static as well as rotating equipment groups), 8.2 % for Electrical, 8.8 % for Instrumentation, 8.1 % for civil, 8.1 % for structural, 8.1 % for fire fighting and HVAC and the remaining 38 % for basic engineering (approximately). Unlike typical EPC disciplines, for the scope of projects executed, the research unit consists of 5 major disciplines namely piping, process , structural (including civil), mechanical and EIT (Electrical and Instrumentation). The percentage distribution of number of responses from the aforementioned disciplines has been almost in-line with typical EPC project weighted values with 22.8 % from piping (almost equal), 22 % from process (more by 14 %), 5 % from mechanical (less by 0.9%), 18 % from Electrical and instrumentation (more by 1.2%) and 13.6 % from structural (less by 2.6 %). The project management work group contributed to 13.6 % of the responses which includes the responses on behalf of the vertical disciplines procurement and construction departments of the project matrix. As expected, owing to lean population of the planning work group, one response contributing to 4.5 % of the overall responses has been recorded. The percentage distribution of research sample population responses based on their work groups in the research unit is graphically shown below in *figure 11.2* using a pie-chart.

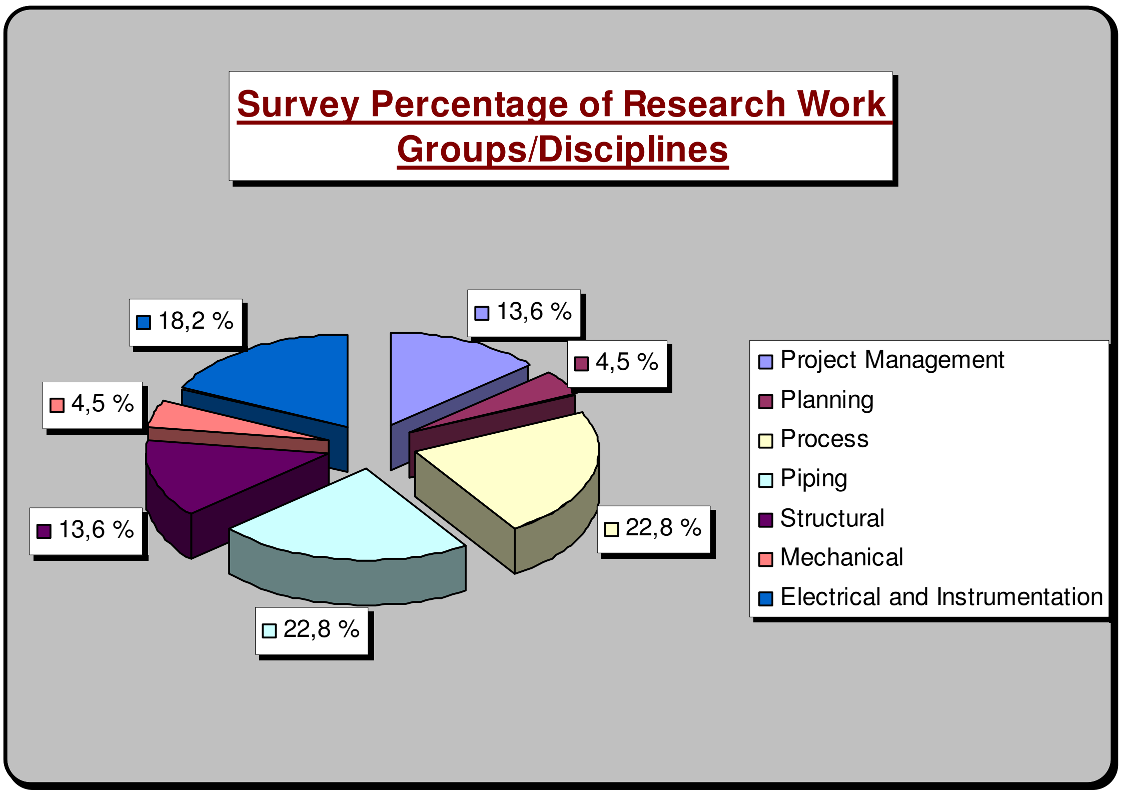


Figure 11.2: Percentage Split of Research Sample Specialisation

11.1.3 Years of Service (@1SRP2)

The profile of the research sample population with respect to their number of years of service in the research unit is summarized in *table 11.3*.

Characteristics	**Classification**	**Samples**	**Research Percentage**
Experience	Less than 1 Year	3	13.6 %

	Between 1 and 5 Years	10	45.4 %
	Between 5 and 10 Years	6	27.3 %
	More Than 10 Years	3	13.6 %
		Total = 22	100 %

Table 11.3: Experience of Research Sample Population

Comment: The number of years of service of the research sample population in the research unit is classified as follows:

1. Less than 1 Year
2. Between 1 and 5 Years
3. Between 5 and 10 Years
4. More Than 10 Years

Based on the responses, only 13.6 % of the respondents have less than one year of service in the research unit and a majority of respondents are under the category of service between one and five years constituting 45 % of the overall sample size. The respondents under the remaining two categories with years of service in the range 5 to 10 years and more than 10 years are termed as mature groups and constitute 27.3 % and 13.6 % respectively of the overall sample. With 86.3 % of the respondents having more than one year of service in the research unit, it can be deemed as sufficient and beneficial input for this research. The frequency distribution of research sample population responses based on their years of service in the research unit is graphically shown in *figure 11.3* using a frequency histogram chart.

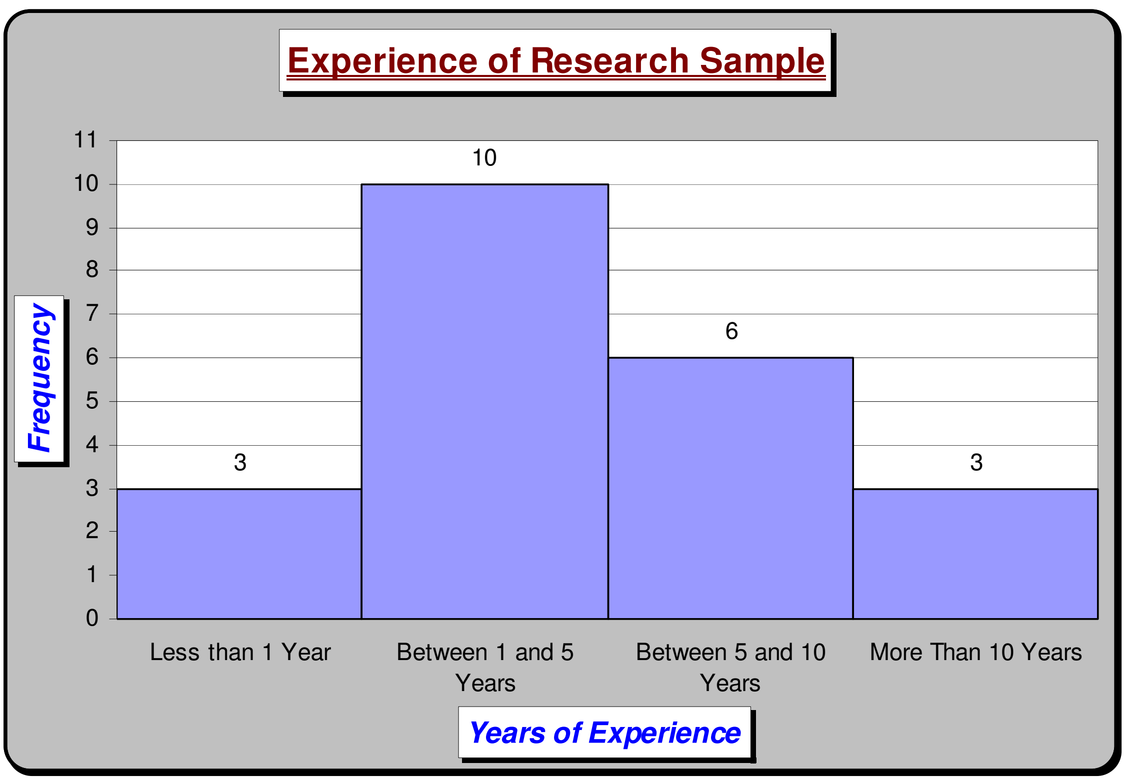


Figure 11.3: Experience Distribution of Research Sample Population

11.1.4 Project Involvement (@1SRP3)

The profile of the research sample population with respect to their involvement in projects at the research unit is summarized in *table 11.4*.

Characteristics	Classification	Samples	Research Percentage
Number of Projects	Less than 1	1	4.5 %
	Between 1 and 5	14	63.6 %
	Between 5 and 10	4	18.2 %
	More Than 10	3	13.6 %
		Total = 22	100 %

Table 11.4: Project Experience of Research Sample Population

Comment: The number of projects the research sample population been a part of in the research unit has been classified as follows in the research questionnaire:

1. Less than 1 Project
2. Between 1 and 5 Projects
3. Between 5 and 10 Projects
4. More Than 10 Projects

Based on the responses, only 4.5 % of the respondents have been a part of less than one project in the research unit and a majority of respondents are under the category of project involvement between one and five projects constituting 63.6 % of the overall sample. The respondents under the remaining two categories with their number of projects involvement in the range 5 to 10 projects and more than 10 projects are termed as mature groups and constitute 18.2 % and 13.6 % respectively of the overall sample. With an outstanding 95.4 % of the respondent's involvement in more than one project during their service in the research unit, it can be deemed as sufficient and beneficial input for this research. The frequency distribution of research sample population responses based on the number of projects involved in the research unit is graphically shown in *figure 11.4* using a frequency histogram chart.

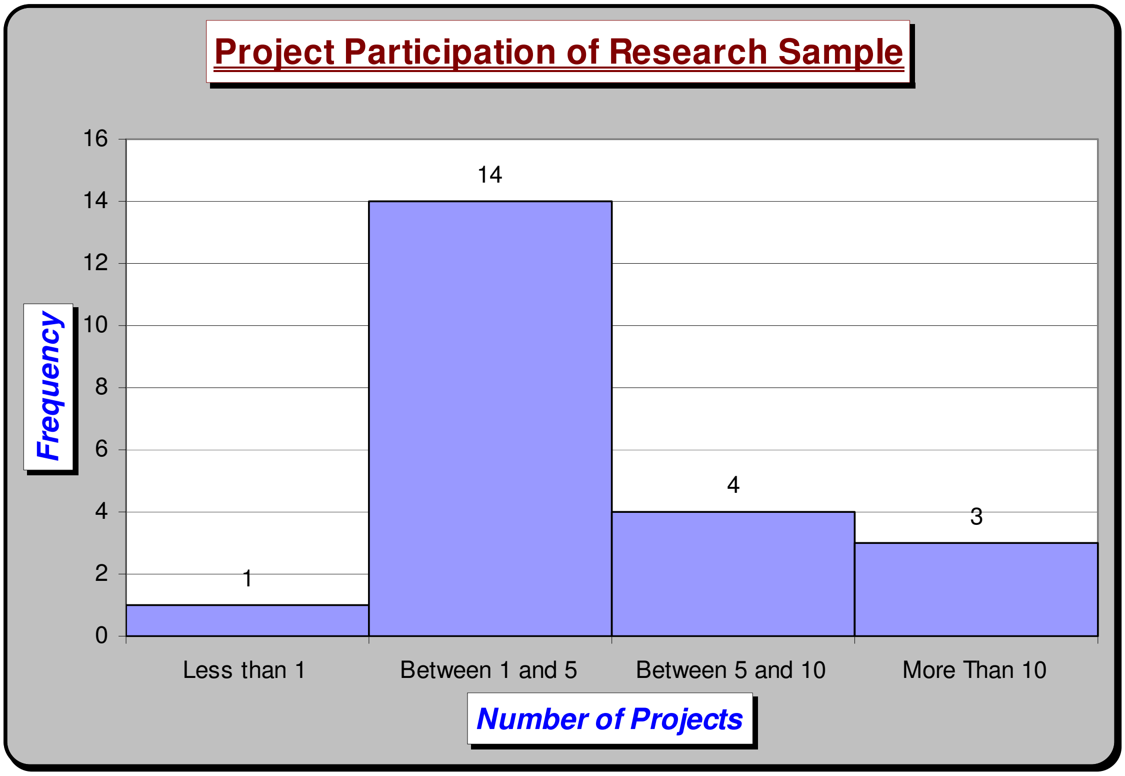


Figure 11.4: Projects Experience Distribution of Research Sample Population

11.2 Project Profile of the Research Unit (PS)

The second section of the questionnaire contains questions intended to draw the percentage spread of the EPC contract compensation models for projects executed along with those that are ongoing at the research unit. The four compensation models namely Lump Sum Price/Reimbursable, Unit Rate/Unit Price, Lump Sum Fixed Price, Cost Reimbursable/Cost Plus/Target Sum discussed in *chapter 3* have been included in the questionnaire. The questions are a part of the *'Project Manager'* questionnaire and the project managers were asked to respond on a percentage scale of 0 % to 100 %. An additional question to find out the complexity of the project being executed against the competency of the organization has been included in second section and has been directed to the Team lead family to respond.

The project profile with respect to the percentage of type of EPC compensation model negotiated with the customer/client at the research unit is summarized in *table 11.5*:

Characteristics	Classification	Samples	Research Percentage
EPC Compensation Model	Lump Sum Price/Reimbursable	3	10.5 %
	Unit Rate/Unit Price	3	26.3 %
	Lump Sum Fixed Price	3	28.9 %
	Cost Reimbursable/Cost Plus/Target Sum		34.2 %

		Total = 22	100 %

Table 11.5: Profile of Compensation Models Negotiated

Comment: Based on the responses from the project manager's, a significant portion of the compensation models negotiated is either unit rate or fixed price or target sum. Only 10.5 % of the projects are based on lump sum reimbursable model wherein all the costs are compensated by the customer/contractor. *Table 11.6* summarizes some of the outcomes that can be expected by the research unit for each of the compensation model negotiated.

Criteria	Compensation Model	Lump Sum Price/Reimbursable (10.5 %)	Unit Rate/Unit Price (26.3 %)	Lump Sum Fixed Price (28.9 %)	Cost Reimbursable/Cost Plus/Target Sum (34.2 %)
Project Scope Definition		High	Low	Medium	High
Client Participation		None	High	None	Low
Risk		Negotiated Rates, Terms and Quantities	N/A	Negotiated Terms and Rates	Negotiated Rates, Terms, Profit, Overhead Costs and Quantities
Incentives for Efficiency		Advantage	Disadvantage	Advantage	Advantage
Commercial Disputes		High	Low	Medium	High
Incentives for Optimisation		High	Low	Low	High

Table 11.6: Impact of Compensation Models on Research Unit

Depending on the response with respect to the choice of projects basing on unit rate, it can be deemed that 23.3 % the projects are prone to variation in project execution activities or in other words the project activities could not quantified. With little less than one-third of the compensation model negotiated being fixed price, the research unit on a positive side has an advantage of banking the incentives (if any) but on the flip side has to bear the contingencies with respect to profit. However, the owner has an advantage of fully defining the scope of work upon signing the contract but leaves a chance for any conflicts with the contractor during execution as a result of variation. The respondents specify that a significant number of compensation models negotiated are Cost Reimbursable/Cost Plus/Target Sum and are of the order 34.2 % of the overall compensation models agreed between the research unit and the customer. This means that the research unit requires significant supervising efforts to translate into control information required to the customer. In addition there is a risk of high commercial disputes between the research unit and the client. The percentage distribution of compensation models negotiated by the research unit for the projects executed and being executed is graphically shown in *figure 11.5* using a pie-chart.

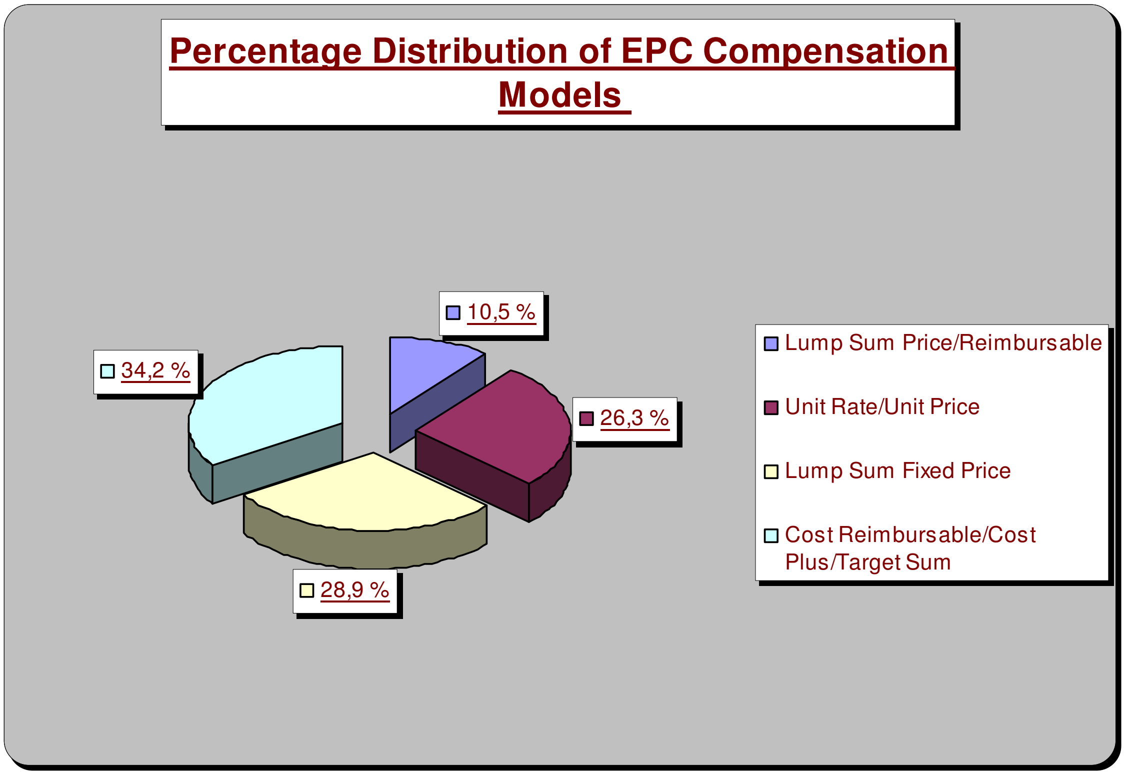


Figure 11.5: Profile of Compensation Models Negotiated by the Research Unit

The frequency distribution of research sample population responses scaling the complexity of the projects being executed against the competency of the research unit is graphically in *figure 11.6* using a frequency histogram chart.

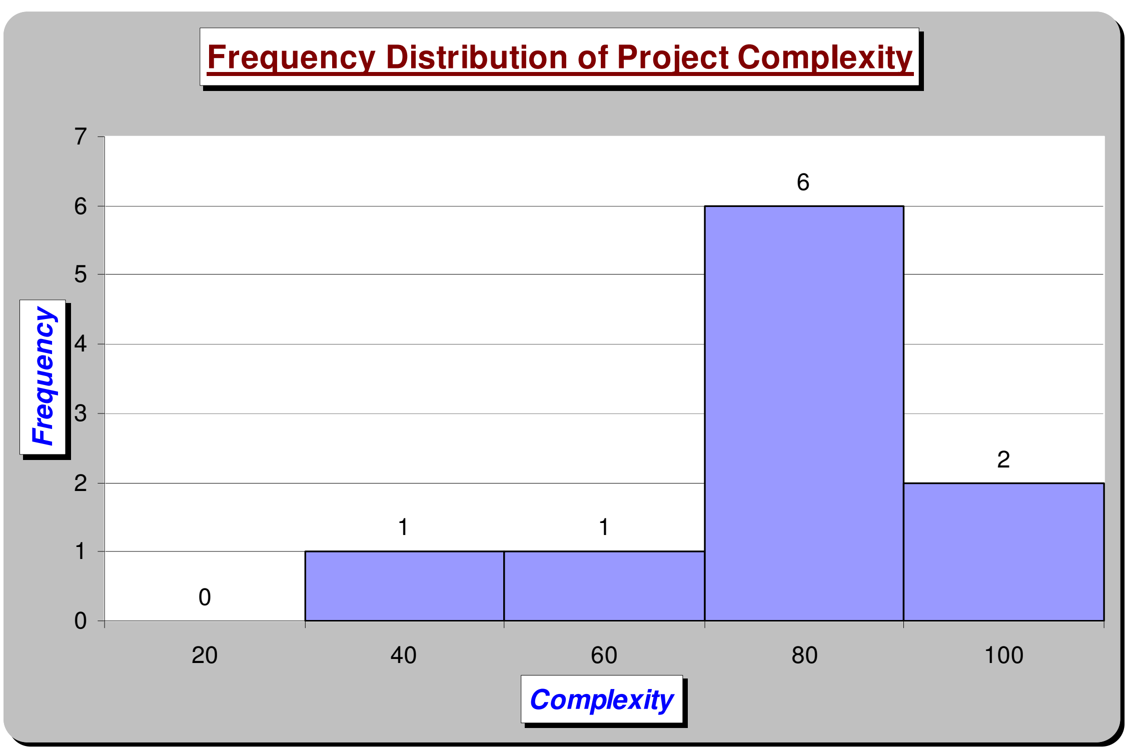


Figure 11.6: Complexity of Projects Executed at the Research Unit

12 Univariate and Reliability Statistics of Critical Success Factors (Observed)

This chapter presents a summary of all the descriptive univariate statistics of all the observed or measured variables and reliability statistics (independent variables only) for each critical success factor discussed in this research in *chapter 9*.

12.1 Univariate and Reliability Statistics of Front End Planning/Start-Up Plan (Observed)

The third section of the research questionnaire consists of six questions for the measurement of the critical success factor '*Front End Planning/Start-Up Plan*'. Front End Planning/Start-Up Plan was measured using one status variable (Availability of organization policies/procedures that govern the budget/schedule estimates for the project execution activities), one dependent variable (Cost/Schedule goals achieved based on policies governing budget/schedule estimates) and 4 independent variables (Accuracy of policies governing budget/schedule estimates, Encouragement from Organization for Start-up Plan formulation, Competency of the teams/team members who formulate the start-up plan, Level of Start-Up Plan alignment for the projects executed or being executed).

Table 12.1 summarizes the quantitative responses gathered from 11 respondents for independent and status variables (3 projects managers and 8 team leads) and 3 respondents for dependent variables (3 Project managers). The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.828 ensuring that the data being analysed is reliable as shown in *table 12.2* and *table 12.3*.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@3SSP1	11	100	0	100	90,91	9,091	30,151	909,091	-3,317	,661	11,000	1,279
@3ISP2	11	60	40	100	65,45	6,085	20,181	407,273	,053	,661	-1,000	1,279
@3DSP3	3	20	60	80	73,33	6,667	11,547	133,333	-1,732	1,225	.	.
@3ISP4	11	60	40	100	74,55	5,455	18,091	327,273	-,344	,661	-,054	1,279
@3ISP5	11	60	40	100	63,64	5,270	17,477	305,455	,690	,661	,779	1,279
@3ISP6	11	60	20	80	60,00	5,394	17,889	320,000	-1,025	,661	1,563	1,279

Table 12.1: Univariate Statistics for Front End Planning/Start-Up Plan (Observed)

Cronbach's Alpha	N of Items
,828	4

Table 12.2: Reliability Statistics for Front End Planning/Start-Up Plan (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@3ISP2	198,18	1876,364	,745	,738
@3ISP4	189,09	2429,091	,465	,862
@3ISP5	200,00	2080,000	,753	,740

@3ISP6	203,64	2145,455	,676	,773
@3ISP2	198,18	1876,364	,745	,738

Table 12.3: Item-Total Statistics for Front End Planning/Start-Up Plan (Observed)

12.2 Univariate and Reliability Statistics of Project Execution (Observed)

The critical success factor project execution was measured using fifteen questions under section four of the questionnaire. Of the fifteen questions five questions are used to measure the causes and the remaining eight for measuring effects. *Table 12.4* summarizes the quantitative responses gathered for the critical success factor *'Project Execution'*. The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.783 ensuring that the data being analyzed is reliable as shown in *table 12.5* and *table 12.6*.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@4IPE1	11	100	0	100	65,91	13,174	43,693	1909,091	-,965	,661	-,978	1,279
@4DPE2	3	20	60	80	73,33	6,667	11,547	133,333	-1,732	1,225	.	.
@4DPE3	3	20	40	60	53,33	6,667	11,547	133,333	-1,732	1,225	.	.
@4DPE4	3	20	60	80	73,33	6,667	11,547	133,333	-1,732	1,225	.	.
@4DPE5	3	20	80	100	93,33	6,667	11,547	133,333	-1,732	1,225	.	.
@4IPE6	11	80	20	100	72,73	6,754	22,401	501,818	-1,199	,661	2,334	1,279
@4IPE7	11	60	40	100	70,91	6,803	22,563	509,091	,118	,661	-1,306	1,279
@4DPE8	3	0	60	60	60,00	,000	,000	,000	.	.	.	.
@4DPE9	3	20	60	80	66,67	6,667	11,547	133,333	1,732	1,225	.	.
@4IPE10	11	80	20	100	69,09	7,318	24,271	589,091	-,692	,661	,285	1,279
@4IPE13	19	80	20	100	60,00	4,837	21,082	444,444	-,318	,524	-,053	1,014

Table 12.4: Univariate Statistics for Project Execution (Observed)

Cronbach's Alpha	N of Items
,783	5

Table 12.5: Reliability Statistics for Project Execution (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@4IPE1	267,50	5478,571	,655	,741
@4IPE6	263,75	7248,214	,948	,636
@4IPE7	266,25	8819,643	,503	,761
@4IPE10	268,75	9891,071	,172	,853
@4IPE13	278,75	7862,500	,821	,681

Table 12.6: Item-Total Statistics for Project Execution (Observed)

12.3 Univariate and Reliability Statistics of Best Practices (Observed)

A total of thirty questions are used to measure five dependent variables and twenty two independent variables to record the state of best practices in the research unit. Majority of the questions in the section included all the three respondent groups to participate in answering**.** *Table 12.7* summarizes the quantitative responses gathered for the critical success factor *'Best Practices'*. The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.703 ensuring that the data being analyzed is reliable as shown in *table 12.8* and *table 12.9*.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@5DBP1	3	20	60	80	73,33	6,667	11,547	133,333	-1,732	1,225	.	.
@5DBP2	3	20	40	60	46,67	6,667	11,547	133,333	1,732	1,225	.	.
@5DBP3	3	20	20	40	33,33	6,667	11,547	133,333	-1,732	1,225	.	.
@5IBP4	22	60	40	100	65,45	3,764	17,655	311,688	,317	,491	-,345	,953
@5IBP5	22	80	20	100	59,09	3,831	17,971	322,944	,095	,491	,510	,953
@5IBP6	22	100	0	100	73,86	5,573	26,138	683,171	-1,552	,491	2,492	,953
@5IBP7	22	100	0	100	38,64	7,489	35,125	1233,766	,465	,491	-1,295	,953
@5IBP8	22	100	0	100	69,32	6,356	29,813	888,799	-1,371	,491	1,201	,953
@5IBP9	22	100	0	100	56,82	6,818	31,980	1022,727	-,414	,491	-1,146	,953
@5IBP10	22	100	0	100	68,18	7,389	34,660	1201,299	-1,111	,491	-,011	,953
@5IBP11	22	100	0	100	42,05	9,067	42,529	1808,712	,423	,491	-1,631	,953
@5IBP12	19	100	0	100	63,16	9,817	42,792	1831,140	-,719	,524	-1,339	1,014
@5IBP13	22	100	0	100	70,45	6,504	30,508	930,736	-1,349	,491	1,086	,953
@5IBP14	19	100	0	100	51,32	8,859	38,616	1491,228	-,300	,524	-1,637	1,014
@5IBP15	22	80	20	100	60,00	5,096	23,905	571,429	-,184	,491	-,685	,953
@5IBP17	22	100	0	100	20,45	8,328	39,064	1525,974	1,649	,491	,956	,953
@5DBP18	22	100	0	100	34,09	7,084	33,225	1103,896	1,126	,491	,111	,953
@5IBP19	19	60	40	100	66,32	4,602	20,058	402,339	,015	,524	-1,068	1,014
@5IBP20	19	60	40	100	71,58	3,844	16,754	280,702	-,277	,524	-,178	1,014
@5IBP21	19	80	20	100	61,05	4,181	18,225	332,164	-,112	,524	,820	1,014
@5DBP22	19	80	20	100	64,21	5,204	22,685	514,620	-,204	,524	-,861	1,014
@5IBP23	19	80	20	100	66,32	4,849	21,137	446,784	-,402	,524	-,125	1,014
@5IBP24	19	75	25	100	75,00	7,404	32,275	1041,667	-,866	,524	-1,059	1,014
@5IBP25	22	75	25	100	79,55	5,365	25,162	633,117	-1,322	,491	,997	,953
@5IBP26	22	100	0	100	40,91	7,635	35,812	1282,468	,500	,491	-1,249	,953
@5IBP27	22	80	20	100	53,64	5,162	24,210	586,147	-,027	,491	-,974	,953

Table 12.7: Univariate Statistics for Best practices (Observed)

Cronbach's Alpha	N of Items
,703	23

Table 12.8: Reliability Statistics for Best practices (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@5IBP4	1281,05	47259,942	,421	,776
@5IBP5	1288,42	47786,257	,344	,682
@5IBP6	1273,68	45177,339	,426	,765
@5IBP7	1309,21	48367,398	,085	,708
@5IBP8	1280,26	43865,205	,477	,755
@5IBP9	1290,79	51520,175	-,102	,630
@5IBP10	1280,26	45073,538	,291	,678
@5IBP11	1302,63	42942,690	,324	,770
@5IBP12	1284,21	44978,509	,235	,687
@5IBP13	1272,37	45651,023	,373	,771
@5IBP14	1296,05	43843,275	,355	,667
@5IBP15	1289,47	44866,374	,556	,756
@5IBP16	1285,26	46687,427	,436	,672
@5IBP17	1323,68	45760,673	,205	,792
@5DBP18	1314,47	54069,152	-,261	,652
@5IBP19	1281,05	49748,830	,104	,601
@5IBP20	1275,79	48153,509	,360	,783
@5IBP21	1286,32	47541,228	,404	,779
@5IBP23	1281,05	49926,608	,075	,603
@5IBP24	1272,37	46526,023	,252	,784
@5IBP25	1269,74	50851,316	-,039	,716
@5IBP26	1309,21	54659,064	-,287	,659
@5IBP27	1294,74	49076,316	,123	,700

Table 12.9: Item-Total Statistics for Best practices (Observed)

12.4 Univariate and Reliability Statistics of ICT (Observed)

The sixth section of the questionnaire consists of six questions intended to measure the independent variables. The response is gathered from 8 Team Lead's and 11 Team Members. *Table 12.10* summarizes the quantitative responses gathered for the measurement of critical success factor *'Information and Communications Technology'*. The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.737 ensuring that the data being analyzed is reliable as shown in *table 12.11* and *table 12.12*.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted

	1281,05	47259,942	,421	,776
@6IICT1	1288,42	47786,257	,344	,682
@6IICT2	1273,68	45177,339	,426	,765
@6IICT3	1309,21	48367,398	,085	,708
@6IICT4	1280,26	43865,205	,477	,755
@6IICT5	1290,79	51520,175	-,102	,630
@6IICT6	1280,26	45073,538	,291	,678

Table 12.10: Univariate Statistics for Information and Communications Technology (Observed)

Cronbach's Alpha	N of Items
,737	6

Table 12.11: Reliability Statistics for Information and Communications Technology (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@6IICT1	324,21	4870,175	,515	,699
@6IICT2	332,63	4276,023	,528	,684
@6IICT3	335,79	4070,175	,566	,671
@6IICT4	333,68	4846,784	,467	,706
@6IICT5	350,53	4638,596	,353	,736
@6IICT6	349,47	3971,930	,486	,702

Table 12.12: Item-Total Statistics for Information and Communications Technology (Observed)

12.5 Univariate and Reliability Statistics of Project Organization (Observed)

Nine independent variables are measured in section seven of the questionnaire with the need to gather data for evaluating the critical success factor *'Project Organization'*. The response is recorded and *table 12.13* summarizes the quantitative responses gathered for the measurement of critical success factor 'Project Organization'. The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.716 ensuring that the data being analyzed is reliable as shown in *table 12.14* and *table 12.15*.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@7IPM1	22	80	20	100	50,91	5,219	24,477	599,134	,142	,491	-,964	,953
@7IPM2	22	80	20	100	82,73	4,222	19,804	392,208	-1,590	,491	3,561	,953
@7IPM3	22	40	60	100	83,64	2,509	11,770	138,528	-,025	,491	,011	,953
@7IPM4	22	60	40	100	79,09	3,349	15,708	246,753	-,566	,491	,499	,953

@7IPM5	19	80	20	100	63,16	5,570	24,279	589,474	-,126	,524	-,524	1,014
@7IPM6	19	80	20	100	56,84	4,900	21,357	456,140	,041	,524	-,325	1,014
@7IPM7	19	80	20	100	65,26	5,481	23,891	570,760	-,351	,524	-,281	1,014
@7IPM8	19	60	40	100	75,79	3,923	17,100	292,398	-,150	,524	-,496	1,014
@7IPM9	19	50	50	100	97,37	2,632	11,471	131,579	-4,359	,524	19,000	1,014
@7SPM10	22	100	0	100	62,50	7,671	35,981	1294,643	-,685	,491	-,993	,953

Table 12.13: Univariate Statistics for Project Organisation (Observed)

Cronbach's Alpha	N of Items
,716	9

Table 12.14: Reliability Statistics for Project Organisation (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@7IPM1	601,58	6091,813	-,289	,701
@7IPM2	567,89	4095,322	,393	,782
@7IPM3	566,84	4911,696	,315	,757
@7IPM4	572,11	4695,322	,285	,749
@7IPM5	586,84	3445,029	,545	,670
@7IPM6	593,16	6378,363	-,365	,793
@7IPM7	584,74	3826,316	,403	,761
@7IPM8	574,21	4036,842	,580	,728
@7IPM9	552,63	5164,912	,177	,692

Table 12.15: Item-Total Statistics for Project Organisation (Observed)

12.6 Univariate and Reliability Statistics of Knowledge Management (Observed)

Section eight of the questionnaire contains seven questions designed to measure six independent variables to record the state of critical success factor *'Knowledge Management'* and the results of the responses is summarized in *table 12.16*. The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.794 ensuring that the data being analyzed is reliable as shown in *table 12.17* and *table 12.18*.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@8IKM1	22	100	0	100	36,36	5,868	27,524	757,576	1,775	,491	2,184	,953
@8IKM2	22	100	0	100	30,68	7,703	36,131	1305,465	,813	,491	-,506	,953

@8IKM3	22	100	0	100	38,64	8,504	39,886	1590,909	,528	,491	-1,434	,953
@8IKM4	22	75	0	75	15,91	5,589	26,215	687,229	1,647	,491	1,554	,953
@8IKM5	22	80	20	100	55,45	4,545	21,320	454,545	,239	,491	-,605	,953
@8IKM6	22	60	20	80	39,09	4,051	19,001	361,039	,830	,491	,039	,953

Table 12.16: Univariate Statistics for Knowledge Management (Observed)

Cronbach's Alpha	N of Items
,794	6

Table 12.17: Reliability Statistics for Knowledge Management (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@8IKM1	179,77	12617,803	,303	,814
@8IKM2	185,45	8699,784	,778	,697
@8IKM3	177,50	7813,690	,829	,680
@8IKM4	200,23	12427,327	,365	,800
@8IKM5	160,68	11836,418	,638	,753
@8IKM6	177,05	12761,093	,496	,780

Table 12.18: Item-Total Statistics for Knowledge Management (Observed)

12.7 Univariate and Reliability Statistics of Benchmarking (Observed)

The last section of the questionnaire intended to measure the critical success factor *'Benchmarking'* consists of four questions of which three are used to gauge independent variables. The response to the independent variables on a scale of five is summarized in *table 12.19*. The internal consistency check for all the independent variables yielded a Cronbach-Alpha coefficient of 0.871 ensuring that the data being analyzed is reliable as shown in *table 12.20* and *table 12.21*.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@9IBM1	11	100	0	100	27,27	14,084	46,710	2181,818	1,189	,661	-,764	1,279
@9IBM2	11	100	0	100	18,18	8,977	29,772	886,364	2,376	,661	6,446	1,279
@9IBM3	11	80	0	80	23,64	8,870	29,419	865,455	,773	,661	-,757	1,279

Table 12.19: Univariate Statistics for Benchmarking (Observed)

Cronbach's Alpha	N of Items
,871	3

Table 12.20: Reliability Statistics for Benchmarking (Observed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@9IBM1	41,82	3106,364	,786	,872
@9IBM2	50,91	5229,091	,758	,834
@9IBM3	45,45	4977,273	,852	,767

Table 12.21: Item-Total Statistics for Benchmarking (Observed)

13 Descriptive and Univariate Statistics of Missing Values

Figure 13.1 shows the overall summary of the missing values in three different pie-charts and *table 13.1* provides an overall summary of the missing values with at least 10 % or missing data.

- The variables chart shows each of the 69 completely observed variable has at least 37 missing data
- The cases chart shows that all the cases have at least one missing variable
- The values chart shows the out of 1518 values required to have a complete dataset 367 values are missing

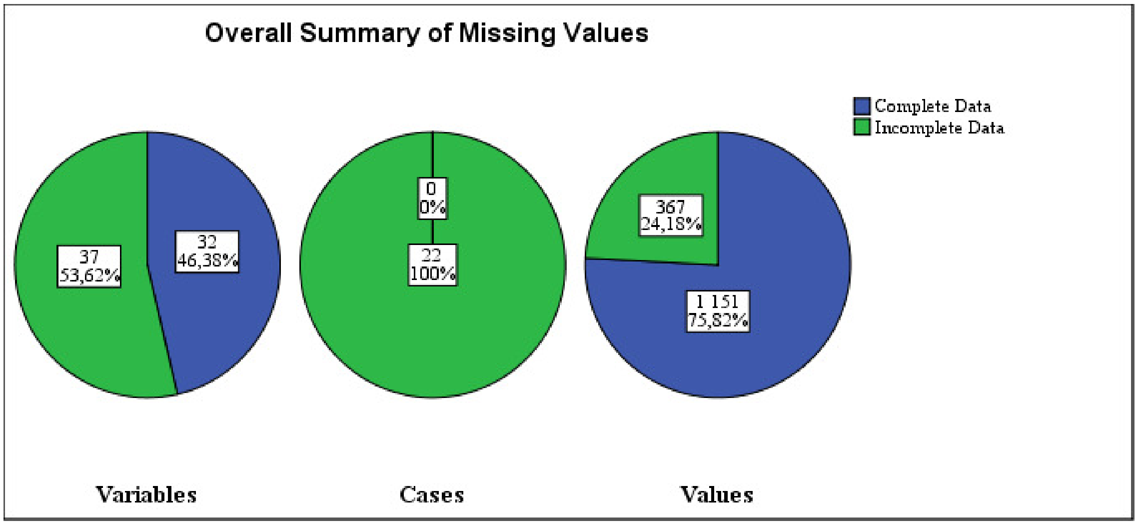


Figure 13.1: Missing Values Summary

	Missing		Valid N	Mean	Std. Deviation
	N	Percent			
@5DBP3	19	86,4%	3	33,33	11,547
@5DBP2	19	86,4%	3	46,67	11,547
@5DBP1	19	86,4%	3	73,33	11,547
@4DPE9	19	86,4%	3	66,67	11,547
@4DPE8	19	86,4%	3	60,00	,000
@4DPE5	19	86,4%	3	93,33	11,547
@4DPE4	19	86,4%	3	73,33	11,547
@4DPE3	19	86,4%	3	53,33	11,547
@4DPE2	19	86,4%	3	73,33	11,547
@3DSP3	19	86,4%	3	73,33	11,547
@9IBM3	11	50,0%	11	23,64	29,419
@9IBM2	11	50,0%	11	18,18	29,772
@9IBM1	11	50,0%	11	27,27	46,710
@4IPE10	11	50,0%	11	69,09	24,271
@4IPE7	11	50,0%	11	70,91	22,563
@4IPE6	11	50,0%	11	72,73	22,401

@4IPE1	11	50,0%	11	65,91	43,693
@3ISP6	11	50,0%	11	60,00	17,889
@3ISP5	11	50,0%	11	63,64	17,477
@3ISP4	11	50,0%	11	74,55	18,091
@3ISP2	11	50,0%	11	65,45	20,181
@3SSP1	11	50,0%	11	90,91	30,151
@7IPM9	3	13,6%	19	97,37	11,471
@7IPM8	3	13,6%	19	75,79	17,100
@7IPM7	3	13,6%	19	65,26	23,891
@7IPM6	3	13,6%	19	56,84	21,357
@7IPM5	3	13,6%	19	63,16	24,279
@6IICT6	3	13,6%	19	55,79	24,566
@5IBP24	3	13,6%	19	75,00	32,275
@5IBP23	3	13,6%	19	66,32	21,137
@5DBP22	3	13,6%	19	64,21	22,685
@5IBP21	3	13,6%	19	61,05	18,225
@5IBP20	3	13,6%	19	71,58	16,754
@5IBP19	3	13,6%	19	66,32	20,058
@5IBP14	3	13,6%	19	51,32	38,616
@5IBP12	3	13,6%	19	63,16	42,792
@4IPE13	3	13,6%	19	60,00	21,082
@8IKM6	0	0,0%	22	39,09	19,001
@8IKM5	0	0,0%	22	55,45	21,320
@8IKM4	0	0,0%	22	15,91	26,215
@8IKM3	0	0,0%	22	38,64	39,886
@8IKM2	0	0,0%	22	30,68	36,131
@8IKM1	0	0,0%	22	36,36	27,524
@7SPM10	0	0,0%	22	62,50	35,981
@7IPM4	0	0,0%	22	79,09	15,708
@7IPM3	0	0,0%	22	83,64	11,770
@7IPM2	0	0,0%	22	82,73	19,804
@7IPM1	0	0,0%	22	50,91	24,477
@6IICT5	0	0,0%	22	57,27	22,505
@6IICT4	0	0,0%	22	70,00	16,036
@6IICT3	0	0,0%	22	66,36	21,722
@6IICT2	0	0,0%	22	72,73	20,043
@6IICT1	0	0,0%	22	80,91	14,445
@5IBP27	0	0,0%	22	53,64	24,210
@5IBP26	0	0,0%	22	40,91	35,812

@5IBP25	0	0,0%	22	79,55	25,162
@5DBP18	0	0,0%	22	34,09	33,225
@5IBP17	0	0,0%	22	20,45	39,064
@5IBP16	0	0,0%	22	61,82	19,429
@5IBP15	0	0,0%	22	60,00	23,905
@5IBP13	0	0,0%	22	70,45	30,508
@5IBP11	0	0,0%	22	42,05	42,529
@5IBP10	0	0,0%	22	68,18	34,660
@5IBP9	0	0,0%	22	56,82	31,980
@5IBP8	0	0,0%	22	69,32	29,813
@5IBP7	0	0,0%	22	38,64	35,125
@5IBP6	0	0,0%	22	73,86	26,138
@5IBP5	0	0,0%	22	59,09	17,971
@5IBP4	0	0,0%	22	65,45	17,655

Table 13.1:Univariate Statistics of Missing Values for Each Variable

The pattern chart shown in *figure 13.2* displays the missing values patterns with each pattern grouped with respect to the three groups of cases of observed and missing data. The pattern chart follows the planned missing data design of the questionnaire used among the three research groups and the variables are arranged in the X-axis of the chart with step wise incremental ordering from left to right depending upon the number of missing values in each case. Since the pattern followed by the missing values is not inline with the characteristic of being monotone, 367 values are required to be imputed to estimate a complete dataset.

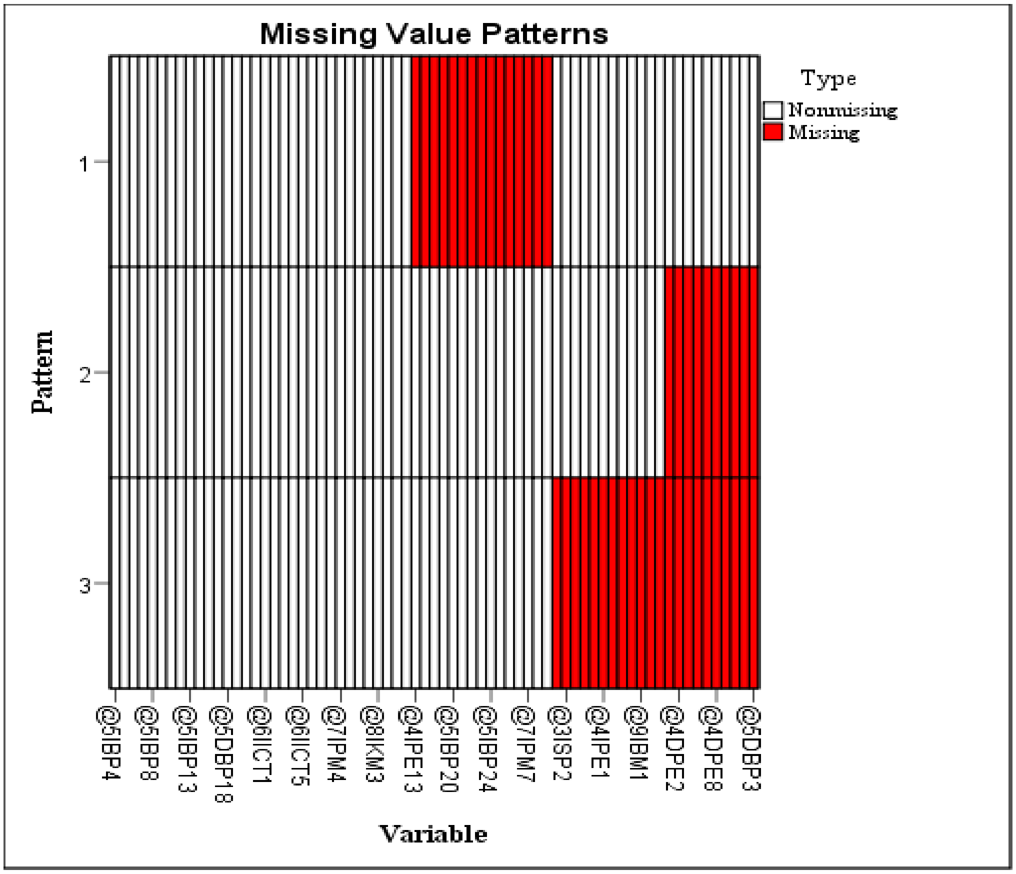


Figure 13.2: Missing Values Pattern

14 Univariate and Reliability Statistics of Critical Success Factors (Imputed)

This chapter presents a summary of descriptive univariate statistics (dependent and independent variables) and reliability statistics (independent variables) for all the imputed missing values for each critical success factor. As the questionnaire was designed for planned missing data, the research used multiple imputation technique to estimate the missing data and found the results obtained to be non-sensitive to the assumption of multivariate normality. The process of imputation consisted of

- Forty iterations of datasets are imputed using SPSS v20.
- Standard errors are estimated for all the variables
- Imputed data is averaged across complete datasets
- The uncertainty as a result of imputing the missing data is recorded by combining the standard errors across the imputed datasets

14.1 Univariate and Reliability Statistics of Front End Planning/Start-Up Plan (Imputed)

Table 14.1 summarizes the univariate statistics for the quantitative imputations deduced through the multiple imputation technique for one dependent and four independent variables. The internal consistency check for all the imputed independent variables yielded a Cronbach-Alpha coefficient of 0.796 ensuring that the data is reliable as shown in *table 14.2* and *table 14.3.*

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@3SSP1	22	100	0	100	91,53	21,15	447,337	-4,21	0,491	18,779	0,953
@3ISP2	22	60	40	100	65,28	14,542	211,473	0,064	0,491	0,642	0,953
@3DSP3	22	20	60	80	73,46	4,604	21,199	-1,021	0,491	2,244	0,953
@3ISP4	22	60	40	100	73,61	12,921	166,942	-0,184	0,491	1,912	0,953
@3ISP5	22	60	40	100	64,71	12,67	160,526	0,539	0,491	2,497	0,953
@3ISP6	22	60	20	80	59,39	12,565	157,885	-1,124	0,491	4,39	0,953

Table 14.1: Univariate Statistics for Front End Planning/Start-up Plan (Imputed)

Cronbach's Alpha	N of Items
0,796	4

Table 14.2: Reliability Statistics for Front End Planning/Start-up Plan (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@3ISP2	197,71	903,823	0,701	0,694
@3ISP4	189,38	1182,96	0,426	0,828
@3ISP5	198,28	1031,86	0,658	0,72

@3ISP6	203,59	1034,83	0,663	0,719

Table 14.3: Item-Total Statistics for Front End Planning/Start-up Plan (Imputed)

14.2 Univariate and Reliability Statistics of Project Execution (Imputed)

The imputed missing values for the critical success factor project execution deduced through the multiple imputation technique are shown using univariate statistics in *table 14.4*. Of the fifteen variables five variables are used to measure the causes and the remaining eight for measuring effects. The internal consistency check on five independent variables yielded a Cronbach-Alpha coefficient of 0.715 ensuring that the data is reliable as shown in *table 14.5* and *table 41.6*.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@4IPE1	22	100	0	100	65,14	30,36	921,739	-1,15	0,491	1,104	0,953
@4DPE2	22	20	60	80	72,83	5,003	25,032	-0,421	0,491	0,576	0,953
@4DPE3	22	20	40	60	53,93	4,752	22,583	-1,007	0,491	2,077	0,953
@4DPE4	22	20	60	80	73,23	4,781	22,861	-0,883	0,491	1,449	0,953
@4DPE5	22	20	80	100	93,39	4,912	24,123	-0,844	0,491	1,413	0,953
@4IPE6	22	80	20	100	73,55	16,137	260,395	-1,533	0,491	5,267	0,953
@4IPE7	22	60	40	100	72,25	15,874	251,997	-0,105	0,491	0,566	0,953
@4DPE8	22	0	60	60	60	0	0	.	.	.	.
@4DPE9	22	20	60	80	67,22	4,509	20,33	0,631	0,491	1,958	0,953
@4IPE10	22	80	20	100	68,69	16,91	285,95	-0,803	0,491	2,959	0,953
@4IPE13	22	80	20	100	59,93	19,522	381,093	-0,326	0,491	0,424	0,953

Table 14.4: Univariate Statistics for Project Execution (Imputed)

Cronbach's Alpha	N of Items
0,715	5

Table 14.5: Reliability Statistics for Project Execution (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted

@4IPE1	274,42	2343,11	0,297	0,662
@4IPE6	266	2677,47	0,719	0,717
@4IPE7	267,31	3260,96	0,345	0,777
@4IPE10	270,87	3549,8	0,15	0,652
@4IPE13	279,63	2683,52	0,531	0,779

Table 14.6: Item-Total Statistics for Project Execution (Imputed)

14.3 Univariate and Reliability Statistics of Best Practices (Imputed)

A total of thirty variables are used to measure five dependent variables and twenty two independent variables to record the state of best practices in the research unit. The imputed missing values for the critical success factor best practices deduced through the multiple imputation technique are shown using univariate statistics in *table 14.7*. The internal consistency check on twenty two independent variables yielded a Cronbach-Alpha coefficient of 0.738 ensuring that the data is reliable as shown in *table 14.8* and *table 14.9*.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@5DBP1	22	20	60	80	74,22	4,67	21,806	-1,226	0,491	2,855	0,953
@5DBP2	22	20	40	60	47,33	4,909	24,103	0,983	0,491	1,739	0,953
@5DBP3	22	20	20	40	33,84	4,509	20,329	-1,191	0,491	3,15	0,953
@5IBP4	22	60	40	100	65,45	17,655	311,688	0,317	0,491	-0,345	0,953
@5IBP5	22	80	20	100	59,09	17,971	322,944	0,095	0,491	0,51	0,953
@5IBP6	22	100	0	100	73,86	26,138	683,171	-1,552	0,491	2,492	0,953
@5IBP7	22	100	0	100	38,64	35,125	1233,77	0,465	0,491	-1,295	0,953
@5IBP8	22	100	0	100	69,32	29,813	888,799	-1,371	0,491	1,201	0,953
@5IBP9	22	100	0	100	56,82	31,98	1022,73	-0,414	0,491	-1,146	0,953
@5IBP10	22	100	0	100	68,18	34,66	1201,3	-1,111	0,491	-0,011	0,953
@5IBP11	22	100	0	100	42,05	42,529	1808,71	0,423	0,491	-1,631	0,953
@5IBP12	22	100	0	100	63,17	39,662	1573,09	-0,762	0,491	-1,007	0,953
@5IBP13	22	100	0	100	70,45	30,508	930,736	-1,349	0,491	1,086	0,953

@5IBP14	22	100	0	100	51,5	35,804	1281,96	-0,334	0,491	-1,333	0,953
@5IBP15	22	80	20	100	60	23,905	571,429	-0,184	0,491	-0,685	0,953
@5IBP16	22	80	20	100	61,82	19,429	377,489	-0,538	0,491	0,679	0,953
@5IBP17	22	100	0	100	20,45	39,064	1525,97	1,649	0,491	0,956	0,953
@5IBP19	22	60	40	100	66,93	18,707	349,959	-0,085	0,491	-0,766	0,953
@5IBP20	22	60	40	100	71,47	15,594	243,167	-0,271	0,491	0,207	0,953
@5IBP21	22	80	20	100	60,53	16,963	287,759	-0,021	0,491	1,294	0,953
@5IBP23	22	80	20	100	66,15	19,643	385,834	-0,398	0,491	0,281	0,953
@5IBP25	22	75	25	100	79,55	25,162	633,117	-1,322	0,491	0,997	0,953
@5IBP26	22	100	0	100	40,91	35,812	1282,47	0,5	0,491	-1,249	0,953
@5IBP27	22	80	20	100	53,64	24,21	586,147	-0,027	0,491	-0,974	0,953

Table 14.7: Univariate Statistics for Best Practices (Imputed)

Cronbach's Alpha	N of Items
0,738	22

Table 14.8: Reliability Statistics for Best Practices (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@5IBP4	1249,5	43693,914	0,406	0,715
@5IBP5	1255,86	43953,445	0,362	0,718
@5IBP6	1241,09	41780,362	0,425	0,705
@5IBP7	1276,31	44164,445	0,109	0,742
@5IBP8	1245,63	40618,25	0,457	0,697
@5IBP9	1258,13	47322,618	-0,097	0,764
@5IBP10	1246,77	41013,362	0,341	0,71
@5IBP11	1272,91	40106,409	0,299	0,716
@5IBP12	1251,78	40768,462	0,291	0,717
@5IBP13	1244,5	42537,066	0,281	0,619
@5IBP14	1263,45	39976,636	0,401	0,7
@5IBP15	1254,95	41802,987	0,473	0,602

@5IBP16	1253,13	43064,852	0,441	0,711
@5IBP17	1294,5	41894,748	0,224	0,727
@5IBP19	1248,02	45842,29	0,101	0,637
@5IBP20	1243,48	44444,508	0,352	0,721
@5IBP21	1254,42	44176,946	0,356	0,62
@5IBP23	1248,8	46486,436	0,015	0,643
@5IBP24	1239,99	42743,577	0,272	0,72
@5IBP25	1235,41	47451,519	-0,099	0,757
@5IBP26	1274,04	49536,38	-0,239	0,787
@5IBP27	1261,31	45055,546	0,132	0,635

Table 14.9: Item-Total Statistics for Best Practices (Imputed)

14.4 Univariate and Reliability Statistics of ICT (Imputed)

The sixth section of the questionnaire consists of six variables intended to measure the independent variables. The three missing values for each of the six variables are imputed through the multiple imputation technique and the consolidated data is described using univariate statistics as shown in table 14.10. The internal consistency check for all the six independent variables yielded a Cronbach-Alpha coefficient of 0.740 ensuring that the data imputed is reliable as shown in *table 14.11* and *table 14.12*.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@6IICT1	22	40	60	100	80,91	14,445	208,658	-0,069	0,491	-0,929	0,953
@6IICT2	22	80	20	100	72,73	20,043	401,732	-0,725	0,491	0,957	0,953
@6IICT3	22	60	40	100	66,36	21,722	471,861	0,272	0,491	-1,145	0,953
@6IICT4	22	60	40	100	70	16,036	257,143	0	0,491	-0,202	0,953
@6IICT5	22	100	0	100	57,27	22,505	506,494	-0,591	0,491	0,919	0,953
@6IICT6	22	100	0	100	55,31	22,899	524,378	-0,519	0,491	0,698	0,953

Table 14.10: Univariate Statistics for Information and Communications Technology (Imputed)

Cronbach's Alpha	N of Items
0,74	6

Table 14.11: Reliability Statistics for Information and Communications Technology (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@6IICT1	321,67	4814,11	0,582	0,689
@6IICT2	329,85	4285,17	0,572	0,676

@6IICT3	336,22	4225,78	0,528	0,688
@6IICT4	332,58	4759,39	0,53	0,695
@6IICT5	345,31	4639,99	0,34	0,748
@6IICT6	347,27	4401,73	0,416	0,726

Table 14.12: Item-Total Statistics for Information and Communications Technology (Imputed)

14.5 Univariate and Reliability Statistics of Project Organization (Imputed)

Nine independent variables are measured in section seven of the questionnaire with the need to gather data for evaluating the critical success factor 'Project Organization'. The three missing values for the five variables are imputed through the multiple imputation technique and the consolidated data is described using univariate statistics as shown in *table 14.13*. The internal consistency check for all the six independent variables yielded a Cronbach-Alpha coefficient of 0.757 ensuring that the data is reliable as shown in *table 14.14* and *table 14.15*.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@7IPM1	22	80	20	100	50,91	24,477	599,134	0,142	0,491	-0,964	0,953
@7IPM2	22	80	20	100	82,73	19,804	392,208	-1,59	0,491	3,561	0,953
@7IPM3	22	40	60	100	83,64	11,77	138,528	-0,025	0,491	0,011	0,953
@7IPM4	22	60	40	100	79,09	15,708	246,753	-0,566	0,491	0,499	0,953
@7IPM5	22	80	20	100	63,95	22,691	514,904	-0,236	0,491	-0,181	0,953
@7IPM6	22	80	20	100	56,83	19,782	391,345	0,045	0,491	0,124	0,953
@7IPM7	22	80	20	100	65,19	22,127	489,609	-0,361	0,491	0,168	0,953
@7IPM8	22	60	40	100	75,85	15,837	250,817	-0,173	0,491	-0,061	0,953
@7IPM9	22	50	50	100	97,73	10,66	113,636	-4,69	0,491	22	0,953
@7SPM10	22	100	0	100	62,5	35,981	1294,64	-0,685	0,491	-0,993	0,953

Table 14.13: Univariate Statistics for Project Organization (Imputed)

Cronbach's Alpha	N of Items
0,757	9

Table 14.14: Reliability Statistics for Project Organization (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@7IPM1	605,01	5457,07	-0,214	0,711
@7IPM2	573,19	3853,74	0,421	0,729
@7IPM3	572,28	4563,71	0,364	0,792
@7IPM4	576,82	4329,89	0,341	0,78
@7IPM5	591,97	3341,41	0,543	0,746
@7IPM6	599,08	5949,58	-0,347	0,615
@7IPM7	590,73	3761,73	0,38	0,639
@7IPM8	580,06	3959,16	0,538	0,71
@7IPM9	558,19	4890,72	0,186	0,736

Table 14.15: Item-Total Statistics for Project Organization (Imputed)

14.6 Univariate and Reliability Statistics of Knowledge Management (Imputed)

Section eight of the questionnaire contains seven questions, designed to measure six independent variables in order to record the state of critical success factor *'Knowledge Management'*. *Table 14.16* summarizes the univariate statistics for the quantitative imputations deduced through the multiple imputation technique for six independent variables. The internal consistency check for all the imputed independent variables yielded a Cronbach-Alpha coefficient of 0.794 ensuring that the data is reliable as shown in *table 14.17* and *table 14.18*.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@8IKM1	22	100	0	100	36,36	27,524	757,576	1,775	0,491	2,184	0,953
@8IKM2	22	100	0	100	30,68	36,131	1305,47	0,813	0,491	-0,506	0,953
@8IKM3	22	100	0	100	38,64	39,886	1590,91	0,528	0,491	-1,434	0,953
@8IKM4	22	75	0	75	15,91	26,215	687,229	1,647	0,491	1,554	0,953
@8IKM5	22	80	20	100	55,45	21,32	454,545	0,239	0,491	-0,605	0,953
@8IKM6	22	60	20	80	39,09	19,001	361,039	0,83	0,491	0,039	0,953

Table 14.16: Univariate Statistics for Knowledge Management (Imputed)

Cronbach's Alpha	N of Items
0,794	6

Table 14.17: Reliability Statistics for Knowledge Management (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@8IKM1	179,77	12617,8	0,303	0,814
@8IKM2	185,45	8699,78	0,778	0,697
@8IKM3	177,5	7813,69	0,829	0,68
@8IKM4	200,23	12427,3	0,365	0,8
@8IKM5	160,68	11836,4	0,638	0,753
@8IKM6	177,05	12761,1	0,496	0,78

Table 14.18: Item-Total Statistics for Knowledge Management (Imputed)

14.7 Univariate Statistics of Benchmarking (Imputed)

The last section of the questionnaire intended to measure the critical success factor *'Benchmarking'* consists of four questions of which three are used as predictor variables. *Table 14.19* summarizes the univariate statistics for the quantitative imputations deduced through the multiple imputation technique for three independent variables. The internal consistency check for all the imputed independent variables yielded a Cronbach-Alpha coefficient of 0.865 ensuring that the data is reliable as shown in *table 14.20* and *table 14.21*.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
@9IBM1	22	100	0	100	27,81	32,533	1058,39	1,461	0,491	1,405	0,953
@9IBM2	22	100	0	100	17,51	20,871	435,609	3,054	0,491	12,187	0,953
@9IBM3	22	80	0	80	24,2	20,5	420,256	0,893	0,491	1,398	0,953

Table 14.19: Univariate Statistics for Benchmarking (Imputed)

Cronbach's Alpha	N of Items
0,865	3

Table 14.20: Reliability Statistics for Benchmarking (Imputed)

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
@9IBM1	41,71	1498,13	0,78	0,857
@9IBM2	52,01	2522,28	0,745	0,828
@9IBM3	45,32	2413,83	0,837	0,762

Table 14.21: Item-Total Statistics for Benchmarking (Imputed)

15 Factor Analysis

15.1 Factor Analysis of Front End Planning/Start-Up Plan

The Factor analysis technique using SPSS v20 has been applied on the four independent variables observed for the first critical success factor *'Front End Planning/Start-Up'*. The four independent variables are accuracy of policies governing budget/schedule estimates (@3ISP2), encouragement from organization for start-up plan formulation (@3ISP4), competency of the teams/team members who formulate the start-up plan (@3ISP5), level of start-up plan alignment for the projects executed or being executed (@3ISP6).

The correlation matrix of the independent observations is shown in *table 15.1* and indicates significant positive correlation between the four input variables measured for front end planning/start-up plan. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.2* and indicated a KMO MSA index more than the required minimum value of 0.6. The anti-image correlation matrix shown in *table 15.3* indicates that the diagonal MSA indexes are well above the required acceptable level of 0.5.

		@3ISP2	@3ISP4	@3ISP5	@3ISP6
Correlation	@3ISP2	1,000	,283	,726	,655
	@3ISP4	,283	1,000	,373	,462
	@3ISP5	,726	,373	1,000	,459
	@3ISP6	,655	,462	,459	1,000
Sig. (1-tailed)	@3ISP2		,101	,000	,000
	@3ISP4	,101		,044	,015
	@3ISP5	,000	,044		,016
	@3ISP6	,000	,015	,016	

Table 15.1: Correlation Matrix of Independent Variables for Front End Planning/Start-Up Plan

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,605
Bartlett's Test of Sphericity	Approx. Chi-Square	30,848
	df	6
	Sig.	,000

Table 15.2: KMO and Bartlett's Test of Independent Variables for Front End Planning/Start-Up Plan

		@3ISP2	@3ISP4	@3ISP5	@3ISP6
Anti-image Covariance	@3ISP2	,327	,102	-,246	-,219
	@3ISP4	,102	,720	-,161	-,237
	@3ISP5	-,246	-,161	,433	,065
	@3ISP6	-,219	-,237	,065	,478
Anti-image Correlation	@3ISP2	,571[a]	,210	-,654	-,555

	@3ISP4	,210	,599[a]	-,288	-,404
	@3ISP5	-,654	-,288	,623[a]	,143
	@3ISP6	-,555	-,404	,143	,634[a]
a. Measures of Sampling Adequacy(MSA)					

Table 15.3: Anti-Image Matrix of Independent Variables for Front End Planning/Start-Up Plan

The statistics defining the total variance of the included variables *(see table 15.4)* reveal that with four variables, only one component or factor is extracted with an Eigen value of more than one. The extracted component accounts for 62.63 % of the cumulative percentage variance.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,505	62,630	62,630	2,505	62,630	62,630
2	,787	19,676	82,306			
3	,517	12,929	95,234			
4	,191	4,766	100,000			
Extraction Method: Principal Component Analysis.						

Table 15.4: Total Variance of Independent Variables for Front End Planning/Start-Up Plan

The Scree plot shown in *figure 15.1* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that only one factor lies above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a one-component solution for the independent variables.

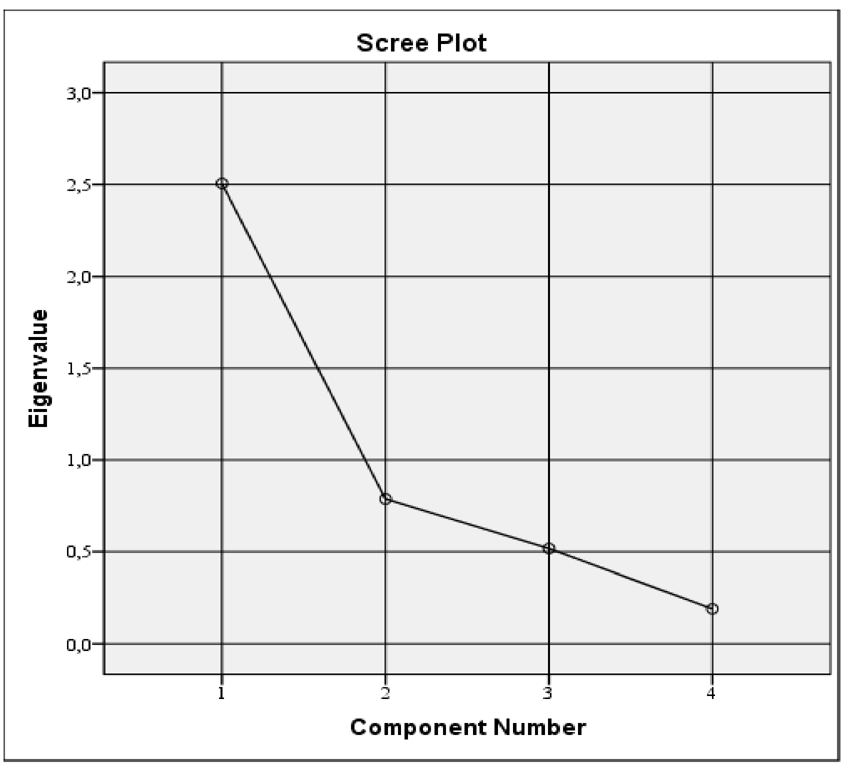


Figure 15.1: Scree Plot of Independent Variables for Front End Planning/Start-Up Plan

In addition to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.5*. The results indicated that the communalities are significantly high for each variable with the remaining included.

	Initial	Extraction
@3ISP2	1,000	,761
@3ISP4	1,000	,386
@3ISP5	1,000	,682
@3ISP6	1,000	,676
Extraction Method: Principal Component Analysis.		

Table 15.5: Communalities of Independent Variables for Front End Planning/Start-Up Plan

The component matrix is extracted using principal component analysis method for all the independent variables under the critical success factor front end planning/start-up plan. The unrotated factor loading results are shown in *table 15.6* and indicate all the four variables are significantly correlated (more than 0.5) with component 1.

Component Matrix[a]	
	Component
	1
@3ISP2	,873
@3ISP4	,621
@3ISP5	,826
@3ISP6	,822
Extraction Method: Principal Component Analysis.	
a. 1 components extracted.	

Table 15.6: Component Matrix of Independent Variables for Front End Planning/Start-Up Plan

With an Eigen value of more than one and maximum factor loading on component 1 for all the included variables, it can be concluded that one variable can be used as a surrogate or derived variable. The research therefore introduces a new variable ***'@3ISPS1'*** and shall be used as a surrogate variable representing all the independent variables observed for critical success factor front end planning/start-up plan.

15.2 Factor Analysis of Project Execution

The Factor analysis technique using SPSS v20 has been applied on the five independent variables observed for the critical success factor '*Project Execution*'. The five independent variables are: Mobilization of Startup resources on time (@4IPE1), Level of integration between the Project disciplines (E, P and C) (@4IPE6), Level of integration between the engineering disciplines (@4IPE7), Effectiveness of Information Technology applications to monitor progress made during project execution (@4IPE10), Timeliness of the dependent disciplines for information (@4IPE13).

The correlation matrix of the independent observations is shown in the *table 15.7* and indicates both positive and negative correlation coefficients among the input variables. However, the correlation is not statistically significant. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.8* and indicated a KMO MSA index less than the required minimum value of 0.6. Hence factor analysis technique is not applicable for the included variables.

		@4IPE1	@4IPE6	@4IPE7	@4IPE10	@4IPE13
Correlation	@4IPE1	1,000	,363	,197	-,153	,408
	@4IPE6	,363	1,000	,703	,367	,451
	@4IPE7	,197	,703	1,000	,027	,098
	@4IPE10	-,153	,367	,027	1,000	,370
	@4IPE13	,408	,451	,098	,370	1,000
Sig. (1-tailed)	@4IPE1		,048	,189	,249	,030
	@4IPE6	,048		,000	,047	,018
	@4IPE7	,189	,000		,453	,333
	@4IPE10	,249	,047	,453		,045
	@4IPE13	,030	,018	,333	,045	

Table 15.7: Correlation Matrix of Independent Variables for Project Execution

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,465
Bartlett's Test of Sphericity	Approx. Chi-Square	33,068
	df	10
	Sig.	,000

Table 15.8: KMO and Bartlett's Test of Independent Variables for Project Execution

The statistics defining the total variance of the included variables *(see table 15.9)* reveal that with five variables, three components or factors could be extracted with an Eigen value more than one. The extracted components account for 89.3 % of the combined cumulative percentage variance.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,242	44,836	44,836	2,242	44,836	44,836	1,651	33,025	33,025
2	1,192	23,837	68,673	1,192	23,837	68,673	1,438	28,766	61,791
3	1,036	20,716	89,389	1,036	20,716	89,389	1,380	27,598	89,389
4	,365	7,294	96,683						
5	,166	3,317	100,000						
Extraction Method: Principal Component Analysis.									

Table 15.9: Total Variance of Independent Variables for Project Execution

The Scree plot shown in *figure 15.2* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that three factors lie above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a three-component solution for the independent variables.

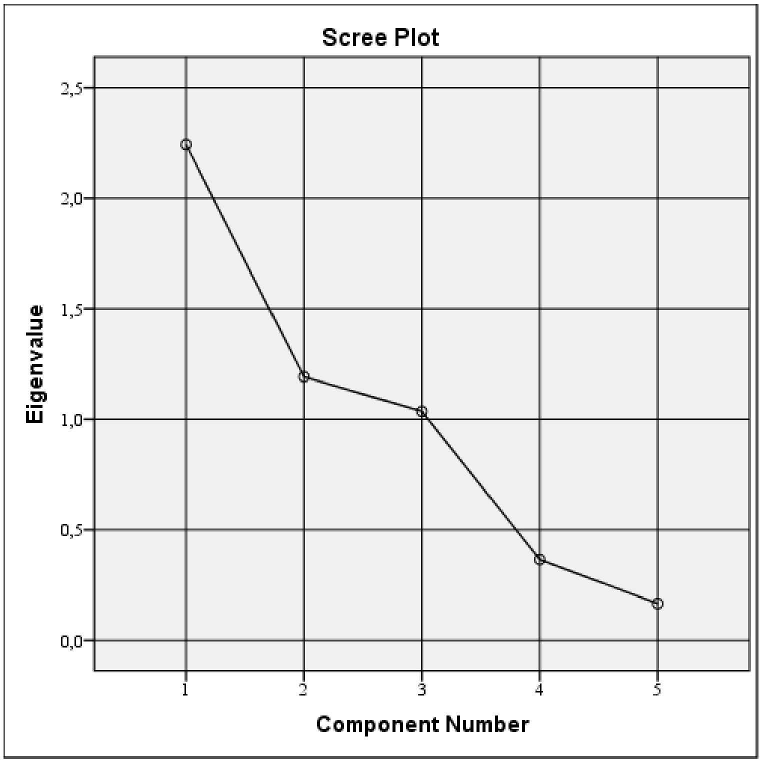


Figure 15.2: Scree Plot of Independent Variables for Project Execution

Further to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.10*. The results indicated that the communalities are significantly high for each variable with the remaining included.

	Initial	Extraction
@4IPE1	1,000	,885
@4IPE6	1,000	,906
@4IPE7	1,000	,936
@4IPE10	1,000	,904
@4IPE13	1,000	,839
Extraction Method: Principal Component Analysis.		

Table 15.10: Communalities of Independent Variables for Project Execution

The component matrix is extracted using principal component analysis method for all the independent variables under the critical success factor project execution. The unrotated factor loading component matrix results are shown in *table 15.11* and indicate all the five variables are significantly correlated (more than 0.5) with either one of the three components extracted. This supports the interpretation made from Eigen values.

Component Matrix[a]			
	Component		
	1	2	3
@4IPE1	,549	-,505	,574
@4IPE6	,915		

@4IPE7	,668		-,591
@4IPE10		,844	
@4IPE13	,692		,527
Extraction Method: Principal Component Analysis.			
a. 3 components extracted.			

Table 15.11: Component Matrix of Independent Variables for Project Execution

With three components extracted, the factor analysis solution has to be rotated. The rotation does not alter the underlying solution, but rather illustrates the pattern of loadings for ease of interpretation. The researcher adapted the Varimax and Kaiser Normalisation technique for rotation and the results are shown in *table 15.12*. The main loadings on component 1 are @4IPE6 and @4IPE7, on component 2 @4IPE1 and @4IPE13, and on component 3 @4IPE10.

Rotated Component Matrix[a]			
	Component		
	1	2	3
@4IPE1		,896	
@4IPE6	,820		
@4IPE7	,965		
@4IPE10			,943
@4IPE13		,722	,560
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 4 iterations.			

Table 15.12: Rotated Component Matrix of Independent Variables for Project Execution

With an Eigen value of more than one on three components and strong factor loadings on three components for all the included variables, three surrogate variables can be deduced representing the five variables. The research henceforth introduces three new surrogate variables ***'@4IPES1'*** (representing @4IPE6 and @4IPE7), ***'@4IPES2'*** (representing @4IPE1 and @4IPE13) and ***'@4IPES3'*** (representing @4IPE10) for the critical success factor project execution.

15.3 Factor Analysis of Best Practices/Quality Control Practices

The Factor analysis technique using SPSS v20 has been applied on the twenty two independent variables observed for the critical success factor '*Best Practices/Quality Control Practices*'. The twenty two independent variables are: Flexibility of disciplines with respect to adapting the best practices (@5IBP4), Robustness of interdisciplinary best practices (@5IBP5), Best practices driven to satisfy client requirements (@5IBP6), Best practices driven by Developments in Technology (@5IBP7), Best practices driven by the need to improve engineering quality (@5IBP8), Best practices driven by the need to improve construction quality (@5IBP9), Best practices driven by the goal to execute work for the estimated cost and planned schedule (@5IBP10), Best practices driven by competitors (@5IBP11), Procedures/work instructions clearly defining the scope of responsibility (@5IBP12), Best practices driven by the need to maintain consistency of product/service (@5IBP13), Procedures/work instructions clearly defining the expectations of your responsibility (@5IBP14), Efficiency of tool/system/philosophy to review/analyse/optimise the work processes (@5IBP15), Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution (@5IBP16), Dedicated team to identify and implement the use best practices in project execution (@5IBP17), Level of on job Quality

Control practices/reviews followed on the job (@5IBP19), Quality of information from dependents (@5IBP20), Timeliness of information from dependents (@5IBP21), Effect of planning on the quality of deliverables (@5IBP23), Feedback on the quality of information provided (@5IBP24), Feedback on the quality of information received (@5IBP25), Documentation/recording/transferring of the feedback received from dependents into a procedure/best practice (@5IBP26), Level of participation/involvement in procedure or work process formulation (@5IBP27).

The correlation matrix of the independent observations is shown in the table 15.13 and indicates both positive and negative correlation coefficients among the input variables. However, the correlation is not statistically significant. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test indicated a KMO MSA index less than the required minimum value of 0.6. Hence factor analysis technique is not applicable for the included variables.

		@5IBP4	@5IBP5	@5IBP6	@5IBP7	@5IBP8	@5IBP9	@5IBP10	@5IBP11	@5IBP12	@5IBP13	@5IBP14
Correlation	@5IBP4	1	0,377	0,169	-0,126	0,333	-0,28	0,258	-0,066	0,403	0,579	0,438
	@5IBP5	0,377	1	0,251	0,285	0,168	-0,32	0,028	0,208	0,352	0,253	0,446
	@5IBP6	0,169	0,251	1	0,407	-0,085	-0,168	-0,042	0,42	0,245	0,441	0,193
	@5IBP7	-0,126	0,285	0,407	1	-0,036	-0,007	0,056	0,554	-0,079	0,227	-0,199
	@5IBP8	0,333	0,168	-0,085	-0,036	1	0,448	0,796	0,033	-0,064	0,101	0,152
	@5IBP9	-0,28	-0,32	-0,168	-0,007	0,448	1	0,42	0,151	-0,595	0,125	-0,461
	@5IBP10	0,258	0,028	-0,042	0,056	0,796	0,42	1	0,224	-0,105	0,194	0,033
	@5IBP11	-0,066	0,208	0,42	0,554	0,033	0,151	0,224	1	-0,051	0,384	-0,213
	@5IBP12	0,403	0,352	0,245	-0,079	-0,064	-0,595	-0,105	-0,051	1	0,042	0,849
	@5IBP13	0,579	0,253	0,441	0,227	0,101	0,125	0,194	0,384	0,042	1	0,034
	@5IBP14	0,438	0,446	0,193	-0,199	0,152	-0,461	0,033	-0,213	0,849	0,034	1
	@5IBP15	0,181	0,488	0,114	-0,142	0,568	-0,125	0,402	0,117	0,397	-0,131	0,492
	@5IBP16	0,303	0,605	0,145	-0,178	0,348	-0,174	0,196	0,076	0,431	-0,106	0,578
	@5IBP17	0,141	-0,244	0,053	0,134	0,156	0,193	0,328	0,192	0,106	0,306	0,126
	@5IBP19	0,399	0,19	0,212	-0,202	0,001	-0,401	-0,07	-0,275	0,152	0,05	0,378
	@5IBP20	0,592	0,311	0,384	-0,147	0,109	-0,241	0,152	0,05	0,196	0,428	0,274
	@5IBP21	0,371	0,502	0,377	-0,2	0,131	-0,066	-0,034	0,218	0,367	0,27	0,388
	@5IBP23	0,118	-0,361	-0,125	-0,338	0,345	0,498	0,274	-0,075	-0,131	0,101	-0,079
	@5IBP24	-0,135	-0,089	0,228	0,109	0,23	-0,145	0,086	0,024	0,124	-0,276	0,308
	@5IBP25	-0,219	-0,306	0,099	0,162	-0,083	0,034	-0,27	0,119	-0,236	-0,398	-0,239
	@5IBP26	-0,332	-0,161	-0,012	0,103	-0,246	0,057	-0,364	-0,011	0,063	-0,285	-0,137
	@5IBP27	0,085	0,117	-0,162	-0,201	0,178	-0,034	-0,054	-0,075	0,215	-0,073	0,299

Table 15.13: Correlation Matrix of Independent Variables for Best Practices

The statistics defining the total variance of the included variables *(see table 15.14)* reveal that with twenty two variables, seven components or factors could be extracted with an Eigen value more than one. The extracted components account for 80.2 % of the combined cumulative percentage variance.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4,951	22,503	22,503	4,951	22,503	22,503	3,832	17,417	17,417
2	3,089	14,041	36,544	3,089	14,041	36,544	2,757	12,532	29,950
3	2,550	11,592	48,135	2,550	11,592	48,135	2,693	12,241	42,190
4	2,231	10,141	58,276	2,231	10,141	58,276	2,532	11,507	53,697
5	1,960	8,909	67,185	1,960	8,909	67,185	2,188	9,946	63,644
6	1,626	7,390	74,575	1,626	7,390	74,575	1,871	8,505	72,148
7	1,244	5,656	80,231	1,244	5,656	80,231	1,778	8,083	80,231
8	,881	4,006	84,237						
9	,767	3,487	87,724						
10	,597	2,713	90,438						
11	,533	2,423	92,861						
12	,424	1,925	94,786						
13	,408	1,855	96,641						
14	,237	1,075	97,716						
15	,193	,878	98,594						
16	,132	,599	99,193						
17	,073	,331	99,524						
18	,047	,214	99,737						
19	,043	,193	99,931						
20	,014	,066	99,996						
21	,001	,004	100,000						
22	2,466E-016	1,121E-015	100,000						
Extraction Method: Principal Component Analysis.									

Table 15.14: Total Variance of Independent Variables for Best Practices

The Scree plot shown in *figure 15.3* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that seven factors lie above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a seven-component solution for the independent variables.

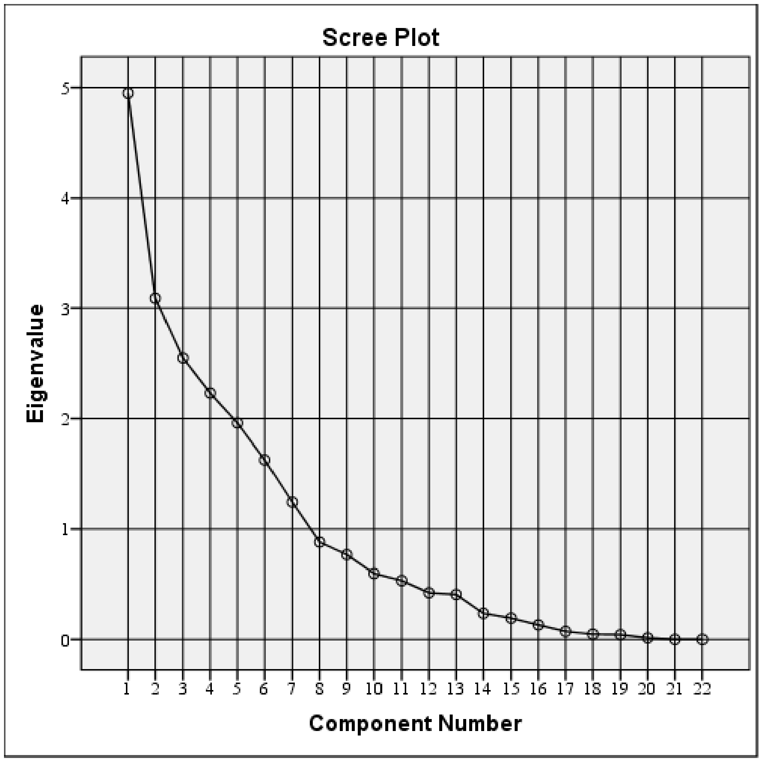


Figure 15.3: Scree Plot of Independent Variables for Best Practices

Further to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.15*. The results indicated that the communalities are significantly high for each variable with the remaining included.

Communalities		
	Initial	Extraction
@5IBP4	1,000	,692
@5IBP5	1,000	,881
@5IBP6	1,000	,772
@5IBP7	1,000	,800
@5IBP8	1,000	,873
@5IBP9	1,000	,803
@5IBP10	1,000	,820
@5IBP11	1,000	,743
@5IBP12	1,000	,869
@5IBP13	1,000	,856
@5IBP14	1,000	,881
@5IBP15	1,000	,795
@5IBP16	1,000	,781
@5IBP17	1,000	,820

@5IBP19	1,000	,886
@5IBP20	1,000	,802
@5IBP21	1,000	,906
@5IBP23	1,000	,856
@5IBP24	1,000	,870
@5IBP25	1,000	,834
@5IBP26	1,000	,568
@5IBP27	1,000	,541
Extraction Method: Principal Component Analysis.		

Table 15.15: Communalities of Independent Variables for Best Practices

The component matrix is extracted using principal component analysis method for all the independent variables under the critical success factor best practices. The unrotated factor loading component matrix results are shown in *table 15.16* and indicate all the twenty two variables are significantly correlated (more than 0.5) with either one of the seven components extracted. This supports the interpretation made from Eigen values.

Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
@5IBP4	,706						
@5IBP5	,688						
@5IBP6			,641				
@5IBP7			,708				
@5IBP8		,650					
@5IBP9		,748					
@5IBP10		,769					
@5IBP11			,640				
@5IBP12	,657						
@5IBP13			,628				
@5IBP14	,781						
@5IBP15	,673						
@5IBP16	,722						
@5IBP17					,699		
@5IBP19						,582	,502
@5IBP20	,646						
@5IBP21	,605				-,642		
@5IBP23		,577					
@5IBP24				,658			
@5IBP25						,661	

@5IBP26							
@5IBP27							
Extraction Method: Principal Component Analysis.							
a. 7 components extracted.							

Table 15.16: Component Matrix of Independent Variables for Best Practices

With seven components extracted, the factor analysis solution has to be rotated. The rotation does not alter the underlying solution, but rather illustrates the pattern of loadings for ease of interpretation. The researcher adapted the Varimax and Kaiser Normalisation technique for rotation and the results are shown in *table 15.17*.

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
@5IBP4			,612				
@5IBP5	,592						
@5IBP6				,735			
@5IBP7				,764			
@5IBP8		,896					
@5IBP9		,502					
@5IBP10		,859					
@5IBP11				,828			
@5IBP12	,829						
@5IBP13				,573	-,545		
@5IBP14	,833						
@5IBP15	,637	,554					
@5IBP16	,780						
@5IBP17							,853
@5IBP19			,883				
@5IBP20			,851				
@5IBP21	,707						
@5IBP23						,861	
@5IBP24					,793		
@5IBP25					,842		
@5IBP26							
@5IBP27							,533
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 15 iterations.							

Table 15.17: Rotated Component Matrix of Independent Variables for Best Practices

With an Eigen value of more than one on seven components and strong factor loadings on seven components for all the included variables, seven surrogate variables can be deduced representing the twenty two variables. The research henceforth introduces seven new variables ***'@5IBPS1'*** (representing @5IBP5, @5IBP12, @5IBP14, @5IBP15, @5IBP16, @5IBP21), ***'@5IBPS2'*** (representing @5IBP8, @5IBP9, @5IBP10), ***'@5IBPS3'*** (representing @5IBP4, @5IBP19, @5IBP20), ***'@5IBPS4'*** (representing @5IBP6, @5IBP7, @5IBP11, @5IBP13), ***'@5IBPS5'*** (representing @5IBP24, @5IBP25), ***'@5IBPS6'*** (representing @5IBP23), ***'@5IBPS7'*** (representing @5IBP17, @5IBP27) as surrogate variables representing the independent variables of best practices.

15.4 Factor Analysis of Information and Communication Technology

The Factor analysis technique using SPSS v20 has been applied on the six input or independent variables observed for the critical success factor *'Information and Communication Technology (ICT)'*. The six independent variables are: Utilization of communication technology among the disciplines/departments/team members (@6IICT1), Level of team's adaptability/responsiveness/flexibility to change in ICT (@6IICT2), Efficiency of the tools/applications/process used as common information repository in the project (@6IICT3), Level of Information and communication tools/applications alignment with project goals and organization goals (@6IICT4), Level of complexity of ICT to receive interdependent information between/across the disciplines (@6IICT5), Level of complexity of the source for retrieving/receiving the information from dependents (@6IICT6).

The correlation matrix of the independent observations is shown in *table 15.18* and indicates significant positive correlation between the input variables measured for ICT. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.19* and indicated a KMO MSA index more than the required minimum value of 0.6. The anti-image correlation matrix shown in *table 15.20* indicates that the diagonal MSA indexes are well above the required acceptable level of 0.5.

Correlation Matrix							
		@6IICT2	@6IICT3	@6IICT4	@6IICT5	@6IICT6	@6IICT1
Correlation	@6IICT2	1,000	,549	,533	,123	,274	,550
	@6IICT3	,549	1,000	,629	,037	,209	,527
	@6IICT4	,533	,629	1,000	,132	,066	,535
	@6IICT5	,123	,037	,132	1,000	,623	,242
	@6IICT6	,274	,209	,066	,623	1,000	,169
	@6IICT1	,550	,527	,535	,242	,169	1,000
Sig. (1-tailed)	@6IICT2		,004	,005	,293	,108	,004
	@6IICT3	,004		,001	,435	,175	,006
	@6IICT4	,005	,001		,279	,385	,005
	@6IICT5	,293	,435	,279		,001	,139
	@6IICT6	,108	,175	,385	,001		,226
	@6IICT1	,004	,006	,005	,139	,226	

Table 15.18: Correlation Matrix of Independent Variables for ICT

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,647
Bartlett's Test of Sphericity	Approx. Chi-Square	40,471
	df	15
	Sig.	,000

Table 15.19: KMO and Bartlett's Test of Independent Variables for ICT

Anti-image Matrices							
		@6IICT2	@6IICT3	@6IICT4	@6IICT5	@6IICT6	@6IICT1
Anti-image Covariance	@6IICT2	,540	-,079	-,129	,086	-,137	-,175
	@6IICT3	-,079	,474	-,219	,135	-,133	-,125
	@6IICT4	-,129	-,219	,490	-,106	,126	-,084
	@6IICT5	,086	,135	-,106	,523	-,340	-,138
	@6IICT6	-,137	-,133	,126	-,340	,507	,077
	@6IICT1	-,175	-,125	-,084	-,138	,077	,553
Anti-image Correlation	@6IICT2	,775[a]	-,155	-,251	,161	-,262	-,319
	@6IICT3	-,155	,700[a]	-,454	,271	-,271	-,244
	@6IICT4	-,251	-,454	,710[a]	-,210	,253	-,161
	@6IICT5	,161	,271	-,210	,427[a]	-,659	-,257
	@6IICT6	-,262	-,271	,253	-,659	,449[a]	,145
	@6IICT1	-,319	-,244	-,161	-,257	,145	,776[a]
a. Measures of Sampling Adequacy(MSA)							

Table 15.20: Anti-Image Matrix of Independent Variables for ICT

The statistics defining the total variance of the included variables *(see table 15.21)* reveal that with six variables, two components or factors are extracted with an Eigen value more than one. The two components account for 47.1% and 24.6 % of the variance respectively with a combined cumulative percentage of 71.7 %.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,826	47,107	47,107	2,826	47,107	47,107	2,650	44,173	44,173
2	1,480	24,662	71,769	1,480	24,662	71,769	1,656	27,596	71,769
3	,569	9,478	81,247						
4	,498	8,299	89,547						
5	,399	6,656	96,203						

6	,228	3,797	100,000						
Extraction Method: Principal Component Analysis.									

Table 15.21: Total Variance of Independent Variables for ICT

The Scree plot shown in *figure 15.4* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that two factors lie above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a two-component solution for the independent variables.

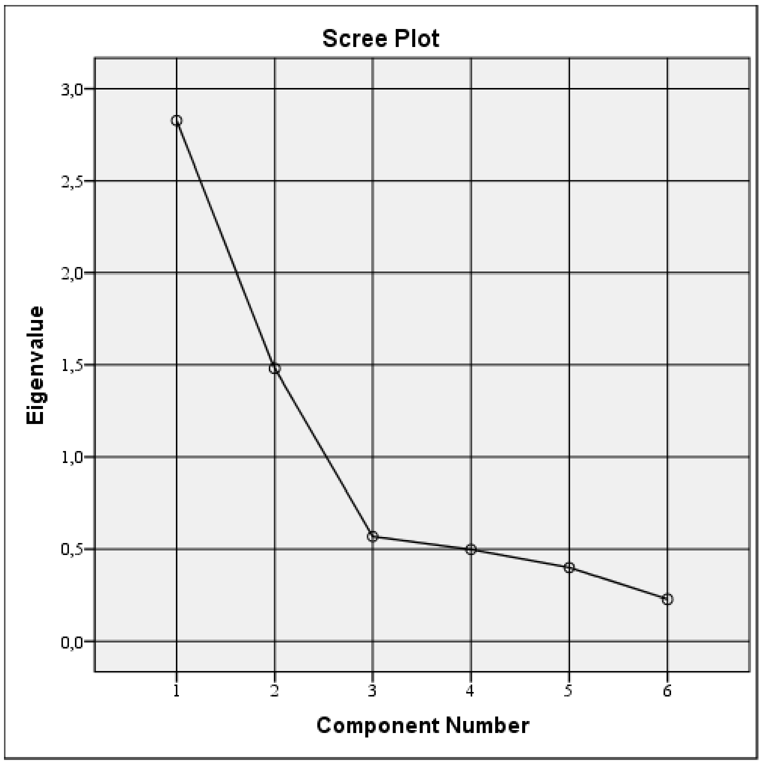


Figure 15.4: Scree Plot of Independent Variables for ICT

Further to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.22*. The results indicated that the communalities are significantly high for each variable with the remaining included.

Communalities		
	Initial	Extraction
@6IICT2	1,000	,650
@6IICT3	1,000	,705
@6IICT4	1,000	,701
@6IICT5	1,000	,812
@6IICT6	1,000	,805
@6IICT1	1,000	,633
Extraction Method: Principal Component Analysis.		

Table 15.22: Communalities of Independent Variables for ICT

The component matrix is extracted using principal component analysis method for all the independent variables under the critical success factor ICT. The unrotated factor loading component matrix results are shown in *table 15.23* and indicate all the six variables are significantly correlated (more than 0.5) with either one of the two components extracted. This supports the interpretation made from Eigen values.

Component Matrix[a]		
	Component	
	1	2
@6IICT2	,795	
@6IICT3	,793	
@6IICT4	,779	
@6IICT5		,817
@6IICT6		,781
@6IICT1	,787	
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

Table 15.23: Component Matrix of Independent Variables for ICT

With two components extracted, the factor analysis solution has to be rotated. The rotation does not alter the underlying solution, but rather illustrates the pattern of loadings for ease of interpretation. The researcher adapted the Varimax and Kaiser Normalisation technique for rotation and the results are shown in *table 15.24*. The main loadings on component 1 are @6IICT1, @6IICT2, @6IICT3 and @6IICT4, while on component 2 two variables @6IICT5, @6IICT6 are loaded.

Rotated Component Matrix[a]		
	Component	
	1	2
@6IICT2	,790	
@6IICT3	,839	
@6IICT4	,837	
@6IICT5		,899
@6IICT6		,888
@6IICT1	,775	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

Table 15.24: Rotated Component Matrix of Independent Variables for ICT

With an Eigen value of more than one on two components and strong factor loadings on two components for all the included variables, two surrogate variables can be deduced representing the six variables. The research henceforth introduces two new surrogate variables ***'@6IICTS1'*** (representing @6IICT1,

@6IICT2, @6IICT3 and @6IICT4) and ***'@6IICTS2'*** (representing @6IICT5 and @6IICT6) for the critical success factor ICT.

15.5 Factor Analysis of Project Organization

The Factor analysis technique using SPSS v20 has been applied on the nine independent variables observed for the critical success factor '*Project Organization*'. The nine independent variables are: Level of complexity involved in finding people to gather information (@7IPM1), Level of trust on team members (@7IPM2), Level of relationship/trust on dependents (@7IPM3), Level of relationship/trust on receivers of information (@7IPM4), Level of opportunity/support from the organization to enhance skills (@7IPM5), Level of non-productivity due to lack of information from dependents (@7IPM6), Flexibility of supervisor to new ideas or processes (@7IPM7), Competency level of supervisor (@7IPM8), Alignment of interest to organization goal (@7IPM9).

The correlation matrix of the independent observations is shown in *table 15.25* and indicates significant positive correlation between the input variables measured for project organization. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.26* and indicated a KMO MSA index more than the required minimum value of 0.6. The anti-image correlation matrix shown in *table 15.27* indicates that the diagonal MSA indexes are mostly well above the required acceptable level of 0.5.

Correlation Matrix										
		@7IPM1	@7IPM2	@7IPM3	@7IPM4	@7IPM5	@7IPM6	@7IPM7	@7IPM8	@7IPM9
Correlation	@7IPM1	1,000	-,182	,186	-,122	-,217	,249	-,460	-,213	,100
	@7IPM2	-,182	1,000	,201	,314	,556	-,468	,502	,386	,256
	@7IPM3	,186	,201	1,000	,637	,279	-,120	,020	,058	,069
	@7IPM4	-,122	,314	,637	1,000	,529	-,383	,306	,041	-,013
	@7IPM5	-,217	,556	,279	,529	1,000	-,363	,617	,457	,039
	@7IPM6	,249	-,468	-,120	-,383	-,363	1,000	-,357	,022	-,036
	@7IPM7	-,460	,502	,020	,306	,617	-,357	1,000	,763	,052
	@7IPM8	-,213	,386	,058	,041	,457	,022	,763	1,000	,224
	@7IPM9	,100	,256	,069	-,013	,039	-,036	,052	,224	1,000
Sig. (1-tailed)	@7IPM1		,209	,203	,295	,166	,132	,016	,171	,330
	@7IPM2	,209		,185	,077	,004	,014	,009	,038	,125
	@7IPM3	,203	,185		,001	,104	,298	,464	,399	,380
	@7IPM4	,295	,077	,001		,006	,039	,083	,429	,477
	@7IPM5	,166	,004	,104	,006		,048	,001	,016	,432
	@7IPM6	,132	,014	,298	,039	,048		,051	,461	,437
	@7IPM7	,016	,009	,464	,083	,001	,051		,000	,408
	@7IPM8	,171	,038	,399	,429	,016	,461	,000		,159
	@7IPM9	,330	,125	,380	,477	,432	,437	,408	,159	

Table 15.25: Correlation Matrix of Independent Variables for Project Organisation

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,609
Bartlett's Test of Sphericity	Approx. Chi-Square	71,050
	df	36
	Sig.	,000

Table 15.26: KMO and Bartlett's Test of Independent Variables for Project Organisation

Anti-image Matrices										
		@7IPM1	@7IPM2	@7IPM3	@7IPM4	@7IPM5	@7IPM6	@7IPM7	@7IPM8	@7IPM9
Anti-image Covariance	@7IPM1	,699	,004	-,111	,043	-,037	-,019	,109	-,044	-,057
	@7IPM2	,004	,524	-,046	,028	-,140	,176	-,018	-,027	-,159
	@7IPM3	-,111	-,046	,454	-,266	,020	,014	,088	-,099	,025
	@7IPM4	,043	,028	-,266	,342	-,131	,021	-,080	,108	-,030
	@7IPM5	-,037	-,140	,020	-,131	,430	,016	-,043	-,042	,068
	@7IPM6	-,019	,176	,014	,021	,016	,539	,118	-,159	,060
	@7IPM7	,109	-,018	,088	-,080	-,043	,118	,176	-,158	,076
	@7IPM8	-,044	-,027	-,099	,108	-,042	-,159	-,158	,226	-,120
	@7IPM9	-,057	-,159	,025	-,030	,068	,060	,076	-,120	,825
Anti-image Correlation	@7IPM1	,734[a]	,006	-,197	,088	-,068	-,031	,310	-,112	-,075
	@7IPM2	,006	,808[a]	-,095	,067	-,294	,331	-,061	-,077	-,242
	@7IPM3	-,197	-,095	,454[a]	-,675	,044	,028	,312	-,308	,041
	@7IPM4	,088	,067	-,675	,551[a]	-,343	,048	-,325	,389	-,057
	@7IPM5	-,068	-,294	,044	-,343	,843[a]	,032	-,156	-,134	,114
	@7IPM6	-,031	,331	,028	,048	,032	,595[a]	,383	-,457	,090
	@7IPM7	,310	-,061	,312	-,325	-,156	,383	,591[a]	-,792	,201
	@7IPM8	-,112	-,077	-,308	,389	-,134	-,457	-,792	,466[a]	-,277
	@7IPM9	-,075	-,242	,041	-,057	,114	,090	,201	-,277	,397[a]
a. Measures of Sampling Adequacy(MSA)										

Table 15.27: Anti-Image Matrix of Independent Variables for Project Organisation

The statistics defining the total variance of the included variables *(see table 15.28)* reveal that out of nine variables, three components or factors could be extracted with an Eigen value more than one. The extracted components account for 69.2 % of the combined cumulative percentage variance.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %

1	3,347	37,192	37,192	3,347	37,192	37,192	2,751	30,571	30,571
2	1,639	18,212	55,404	1,639	18,212	55,404	2,151	23,899	54,470
3	1,246	13,845	69,249	1,246	13,845	69,249	1,330	14,778	69,249
4	,979	10,875	80,124						
5	,647	7,191	87,315						
6	,414	4,598	91,913						
7	,397	4,412	96,325						
8	,236	2,619	98,944						
9	,095	1,056	100,000						
Extraction Method: Principal Component Analysis.									

Table 15.28: Total Variance of Independent Variables for Project Organisation

The Scree plot shown in *figure 15.5* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that three factors lie above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a three-component solution for the independent variables.

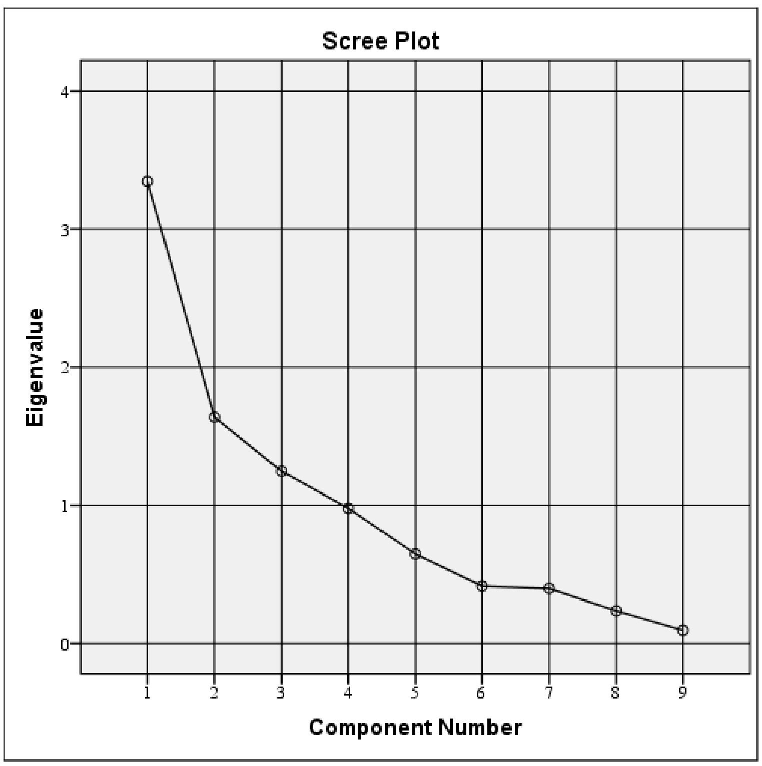


Figure 15.5: Scree Plot of Independent Variables for Project Organisation

Further to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.29*. The results indicated that the communalities are significantly high for each variable with the remaining included.

Communalities		
	Initial	Extraction
@7IPM1	1,000	,651
@7IPM2	1,000	,589
@7IPM3	1,000	,760
@7IPM4	1,000	,808
@7IPM5	1,000	,689
@7IPM6	1,000	,498
@7IPM7	1,000	,857
@7IPM8	1,000	,788
@7IPM9	1,000	,591
Extraction Method: Principal Component Analysis.		

Table 15.29: Communalities of Independent Variables for Project Organisation

The component matrix is extracted using principal component analysis method for all the independent variables under the critical success factor project organization. The unrotated factor loading component matrix results are shown in *table 15.30* and indicate all the nine variables are significantly correlated (more than 0.5) with either one of the three components extracted. This supports the interpretation made from Eigen values.

Component Matrix[a]			
	Component		
	1	2	3
@7IPM1			,530
@7IPM2	,751		
@7IPM3		,771	
@7IPM4	,614	,635	
@7IPM5	,826		
@7IPM6	-,563		
@7IPM7	,833		
@7IPM8	,623		
@7IPM9			,748
Extraction Method: Principal Component Analysis.			
a. 3 components extracted.			

Table 15.30: Component Matrix of Independent Variables for Project Organisation

With three component extracted, the factor analysis solution has to be rotated. The rotation does not alter the underlying solution, but rather illustrates the pattern of loadings for ease of interpretation. The researcher adapted the Varimax and Kaiser Normalisation technique for rotation and the results are shown in *table 15.31*. The main loadings on component 1 are @7IPM2, @7IPM5, @7IPM7 and @7IPM8, on component 2 @7IPM3, @7IPM4 and on component 3 @7IPM1, @7IPM9.

Rotated Component Matrix[a]			
	Component		
	1	2	3
@7IPM1			,680
@7IPM2	,656		
@7IPM3		,815	
@7IPM4		,880	
@7IPM5	,633	,519	
@7IPM6			
@7IPM7	,878		
@7IPM8	,866		
@7IPM9			,677
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 5 iterations.			

Table 15.31: Rotated Component Matrix of Independent Variables for Project Organisation

With an Eigen value of more than one on three components and strong factor loadings on three components for all the included variables, three surrogate variables can be deduced representing the nine variables. The research henceforth introduces three new surrogate variables ***'@7IPMS1'*** (representing @7IPM2, @7IPM5, @7IPM7 and @7IPM8), ***'@7IPMS2'*** (representing @7IPM3 and @7IPM4) and ***'@7IPMS3'*** (representing @7IPM1 and @7IPM9).

15.6 Factor Analysis of Knowledge Management

The Factor analysis technique using SPSS v20 has been applied on the six independent variables observed for the critical success factor '*Knowledge Management'*. The six independent variables are: Frequency of lessons leaned implementation (@8IKM1), Support from organization to identify, implement and use the lessons learned program (@8IKM2), Frequency of Lessons learned getting converted into best practices or procedures (@8IKM3), Availability of dedicated team to identify and implement the lessons learned in project execution (@8IKM4), Culture of lessons learned process or knowledge management in the discipline/project (@8IKM5), Efficiency of tools to register and transfer lessons learned into action (@8IKM6).

The correlation matrix of the independent observations is shown in *table 15.32* and indicates significant positive correlation between the input variables measured for knowledge management. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.33* and indicated a KMO MSA index more than the required minimum value of 0.6. The anti-image correlation matrix shown in *table 15.34* indicates that the diagonal MSA indexes are well above the required acceptable level of 0.5.

Correlation Matrix						
	@8IKM1	@8IKM2	@8IKM3	@8IKM4	@8IKM5	@8IKM6

Correlation	@8IKM1	1,000	,411	,394	-,221	,336	,112
	@8IKM2	,411	1,000	,770	,403	,591	,389
	@8IKM3	,394	,770	1,000	,494	,608	,457
	@8IKM4	-,221	,403	,494	1,000	,221	,413
	@8IKM5	,336	,591	,608	,221	1,000	,460
	@8IKM6	,112	,389	,457	,413	,460	1,000
Sig. (1-tailed)	@8IKM1		,029	,035	,161	,063	,310
	@8IKM2	,029		,000	,032	,002	,037
	@8IKM3	,035	,000		,010	,001	,016
	@8IKM4	,161	,032	,010		,162	,028
	@8IKM5	,063	,002	,001	,162		,016
	@8IKM6	,310	,037	,016	,028	,016	

Table 15.32: Correlation Matrix of Independent Variables for Knowledge Management

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,726
Bartlett's Test of Sphericity	Approx. Chi-Square	48,175
	df	15
	Sig.	,000

Table 15.33: KMO and Bartlett's Test of Independent Variables for Knowledge Management

Anti-image Matrices							
		@8IKM1	@8IKM2	@8IKM3	@8IKM4	@8IKM5	@8IKM6
Anti-image Covariance	@8IKM1	,579	-,104	-,127	,280	-,008	-,020
	@8IKM2	-,104	,362	-,152	-,076	-,103	,012
	@8IKM3	-,127	-,152	,296	-,153	-,104	-,035
	@8IKM4	,280	-,076	-,153	,496	,084	-,150
	@8IKM5	-,008	-,103	-,104	,084	,533	-,175
	@8IKM6	-,020	,012	-,035	-,150	-,175	,679
Anti-image Correlation	@8IKM1	,543[a]	-,227	-,307	,523	-,015	-,032
	@8IKM2	-,227	,801[a]	-,465	-,179	-,234	,024
	@8IKM3	-,307	-,465	,743[a]	-,401	-,261	-,079
	@8IKM4	,523	-,179	-,401	,547[a]	,164	-,258
	@8IKM5	-,015	-,234	-,261	,164	,824[a]	-,290
	@8IKM6	-,032	,024	-,079	-,258	-,290	,826[a]
a. Measures of Sampling Adequacy(MSA)							

Table 15.34: Anti-Image Matrix of Independent Variables for Knowledge Management

The statistics defining the total variance of the included variables *(see table 15.35)* reveal that with six variables, two components or factors could be extracted with an Eigen value more than one. The extracted components account for 73 % of the combined cumulative percentage variance.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,093	51,558	51,558	3,093	51,558	51,558	2,555	42,591	42,591
2	1,291	21,517	73,074	1,291	21,517	73,074	1,829	30,483	73,074
3	,658	10,969	84,044						
4	,480	8,007	92,051						
5	,270	4,508	96,559						
6	,206	3,441	100,000						
Extraction Method: Principal Component Analysis.									

Table 15.35: Total Variance of Independent Variables for Knowledge Management

The Scree plot shown in *figure 15.6* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that two factors lie above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a two-component solution for the independent variables.

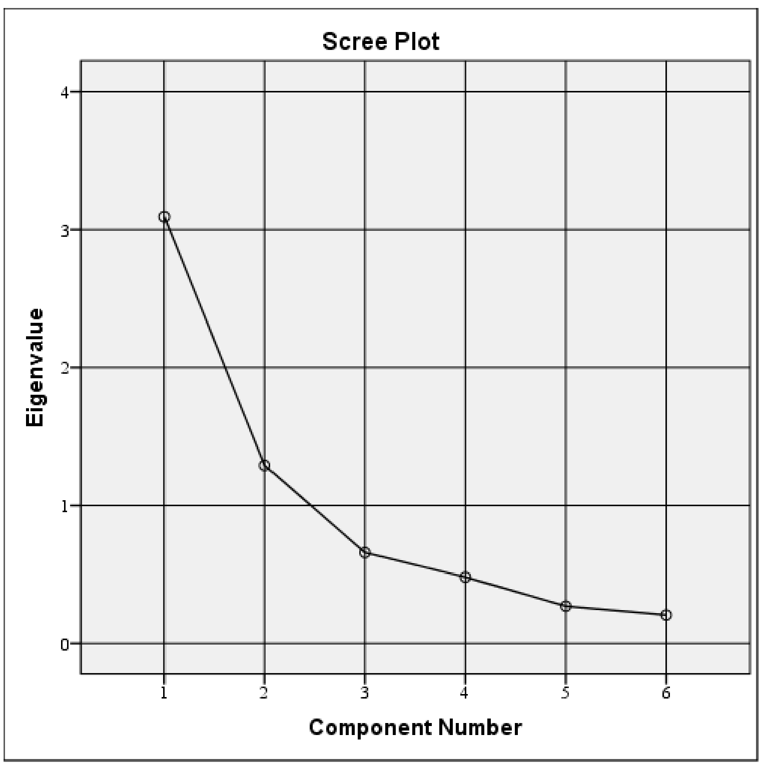


Figure 15.6: Scree Plot of Independent Variables for Knowledge Management

Further to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.36*. The results indicated that the communalities are significantly high for each variable with the remaining included.

Communalities		
	Initial	Extraction
@8IKM1	1,000	,836
@8IKM2	1,000	,760
@8IKM3	1,000	,811
@8IKM4	1,000	,822
@8IKM5	1,000	,634
@8IKM6	1,000	,521
Extraction Method: Principal Component Analysis.		

Table 15.36: Communalities of Independent Variables for Knowledge Management

The component matrix is extracted using principal component analysis method for all the independent variables under the critical success factor knowledge management. The unrotated factor loading component matrix results are shown in *table 15.37* and indicate all the six variables are significantly correlated (more than 0.5) with either one of the two components extracted. This supports the interpretation made from Eigen values.

Component Matrix[a]		
	Component	
	1	2
@8IKM1		,800
@8IKM2	,865	
@8IKM3	,900	
@8IKM4	,545	-,725
@8IKM5	,779	
@8IKM6	,659	
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

Table 15.37: Component Matrix of Independent Variables for Knowledge Management

With two component extracted, the factor analysis solution has to be rotated. The rotation does not alter the underlying solution, but rather illustrates the pattern of loadings for ease of interpretation. The researcher adapted the Varimax and Kaiser Normalisation technique for rotation and the results are shown in *table 15.38*. The main loadings on component 1 are @8IKM1, @8IKM2, @8IKM3 and @8IKM5, while on component 2 are @8IKM4, @8IKM6.

Rotated Component Matrix[a]		
	Component	
	1	2

@8IKM1	,807	
@8IKM2	,784	
@8IKM3	,763	
@8IKM4		,905
@8IKM5	,741	
@8IKM6		,607
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

Table 15.38: Rotated Component Matrix of Independent Variables for Knowledge Management

With an Eigen value of more than one on two components and strong factor loadings on two components for all the included variables, two surrogate variables can be deduced representing the six variables. The research henceforth introduces and uses two new surrogate variables ***'@8IKMS1'*** (representing are @8IKM1, @8IKM2, @8IKM3 and @8IKM5) and ***'@8IKMS2'*** (representing @8IKM4 and @8IKM6) for the critical success factor knowledge management.

15.7 Factor Analysis of Benchmarking

The Factor analysis technique using SPSS v20 has been applied on the three independent variables observed for the first critical success factor '*Benchmarking'*. The three independent variables are availability of benchmarking process (@9IBM1), Frequency of utilisation of benchmarking process (@9IBM2), Quality of benchmarking process (@9IBM3).

The correlation matrix of the independent observations is shown in *table 15.39* and indicates significant positive correlation between the input variables measured for benchmarking. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.40* and indicated a KMO MSA index more than the required minimum value of 0.6. The anti-image correlation matrix shown in *table 15.41* indicates that the diagonal MSA indexes are well above the required acceptable level of 0.5.

Correlation Matrix				
		@9IBM1	@9IBM2	@9IBM3
Correlation	@9IBM1	1,000	,677	,782
	@9IBM2	,677	1,000	,751
	@9IBM3	,782	,751	1,000
Sig. (1-tailed)	@9IBM1		,000	,000
	@9IBM2	,000		,000
	@9IBM3	,000	,000	

Table 15.39: Correlation Matrix of Independent Variables for Benchmarking

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	,732

Bartlett's Test of Sphericity	Approx. Chi-Square	34,977
	df	3
	Sig.	,000

Table 15.40: KMO and Bartlett's Test of Independent Variables for Benchmarking

Anti-image Matrices				
		@9IBM1	@9IBM2	@9IBM3
Anti-image Covariance	@9IBM1	,369	-,086	-,187
	@9IBM2	-,086	,416	-,169
	@9IBM3	-,187	-,169	,298
Anti-image Correlation	@9IBM1	,745[a]	-,219	-,564
	@9IBM2	-,219	,785[a]	-,481
	@9IBM3	-,564	-,481	,681[a]
a. Measures of Sampling Adequacy(MSA)				

Table 15.41: Anti-Image Matrix of Independent Variables for Benchmarking

The statistics defining the total variance of the included variables *(see table 15.42)* reveal that out of four components, only one component or factor was extracted with an Eigen value more than one. The extracted component accounts for 82.48 % of the cumulative percentage variance.

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,474	82,480	82,480	2,474	82,480	82,480
2	,325	10,842	93,322			
3	,200	6,678	100,000			
Extraction Method: Principal Component Analysis.						

Table 15.42: Total Variance of Independent Variables for Benchmarking

The Scree plot shown in *figure 15.7* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that only one factor lies above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a one-component solution for the independent variables.

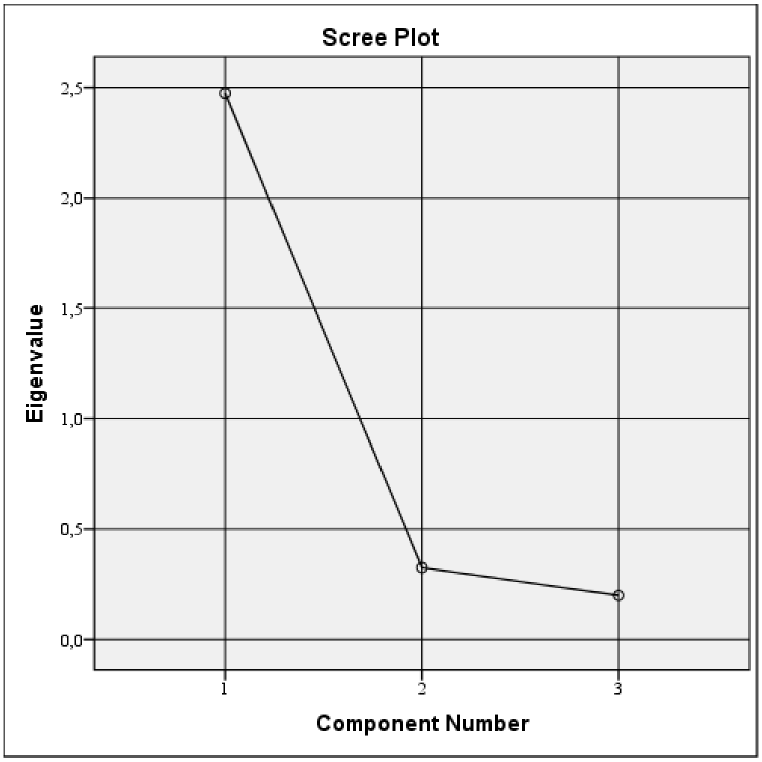


Figure 15.7: Scree Plot of Independent Variables for Benchmarking

In addition to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.43*. The results indicated that the communalities are significantly high for each variable with the remaining included.

Communalities		
	Initial	Extraction
@9IBM1	1,000	,815
@9IBM2	1,000	,791
@9IBM3	1,000	,868
Extraction Method: Principal Component Analysis.		

Table 15.43: Communalities of Independent Variables for Benchmarking

The component matrix extracted using principal component analysis method for all the independent variables under the critical success factor benchmarking. The unrotated factor loading results are shown in *table 15.44* and indicate all the three variables are significantly correlated (more than 0.5) with component 1.

Component Matrix[a]	
	Component
	1
@9IBM1	,903
@9IBM2	,889

@9IBM3	,932
Extraction Method: Principal Component Analysis.	
a. 1 components extracted.	

Table 15.44: Component Matrix of Independent Variables for Benchmarking

With an Eigen value of more than one and maximum factor loading on component 1 for all the included variables, it can be concluded that the one variable can be used as a surrogate or derived variable. The research therefore introduces a new variable ***'@9IBMS1'*** that shall be used as a surrogate variable representing all the independent variables observed for critical success factor benchmarking.

15.8 Factor Analysis of Dependent Variables

The Factor analysis technique using SPSS v20 has been applied on the eleven output or dependent variables observed in the research. The eleven dependent variables are: Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3), Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22).

The correlation matrix of the dependent observations is shown in the *table 15.45* and indicates both positive and negative correlation of all the output variables. The Bartlett's Test of Sphericity indicated an overall significance index of 0 (Sig. = 0.000) and confirms the absence of extreme singularity or extreme multicollinearity among the included variables. The statistical test Kaiser-Meyer-Olkin Measure of Sampling Adequacy is used to confirm the appropriateness of applying the factor analysis technique on the included variables. The results of the test are shown in *table 15.46* and indicated a KMO MSA index more than the required minimum value of 0.6. The anti-image correlation matrix shown in *table 15.47* indicates that the diagonal MSA indexes are well above the required acceptable level of 0.5.

		@3DSP3	@4DPE2	@4DPE3	@4DPE4	@4DPE5	@4DPE9	@5DBP1	@5DBP2	@5DBP3	@5DBP18	@5DBP22
Correlation	@3DSP3	1,000	,459	-,186	,637	,756	,312	,549	,135	,622	,179	,204
	@4DPE2	,459	1,000	-,164	,490	,569	,377	,444	,231	,660	-,030	-,168
	@4DPE3	-,186	-,164	1,000	-,276	-,331	-,614	-,261	-,635	-,355	-,131	,154
	@4DPE4	,637	,490	-,276	1,000	,570	,314	,591	,203	,480	,091	,081
	@4DPE5	,756	,569	-,331	,570	1,000	,324	,559	,292	,593	,023	,106
	@4DPE9	,312	,377	-,614	,314	,324	1,000	,136	,486	,229	,056	-,079
	@5DBP1	,549	,444	-,261	,591	,559	,136	1,000	,264	,619	,361	,294
	@5DBP2	,135	,231	-,635	,203	,292	,486	,264	1,000	,197	,279	,166
	@5DBP3	,622	,660	-,355	,480	,593	,229	,619	,197	1,000	,159	,028
	@5DBP18	,179	-,030	-,131	,091	,023	,056	,361	,279	,159	1,000	,509
	@5DBP22	,204	-,168	,154	,081	,106	-,079	,294	,166	,028	,509	1,000
Sig. (1-tailed)	@3DSP3		,016	,204	,001	,000	,079	,004	,275	,001	,213	,181
	@4DPE2	,016		,232	,010	,003	,042	,019	,151	,000	,446	,227
	@4DPE3	,204	,232		,107	,066	,001	,120	,001	,052	,281	,247
	@4DPE4	,001	,010	,107		,003	,078	,002	,183	,012	,343	,361
	@4DPE5	,000	,003	,066	,003		,071	,003	,093	,002	,460	,319
	@4DPE9	,079	,042	,001	,078	,071		,272	,011	,153	,402	,364
	@5DBP1	,004	,019	,120	,002	,003	,272		,118	,001	,050	,092
	@5DBP2	,275	,151	,001	,183	,093	,011	,118		,190	,104	,230
	@5DBP3	,001	,000	,052	,012	,002	,153	,001	,190		,239	,450
	@5DBP18	,213	,446	,281	,343	,460	,402	,050	,104	,239		,008
	@5DBP22	,181	,227	,247	,361	,319	,364	,092	,230	,450	,008	

Table 15.45: Correlation Matrix of Dependent Variables

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,625
Bartlett's Test of Sphericity	Approx. Chi-Square	103,679
	df	55
	Sig.	,000

Table 15.46: KMO and Bartlett's Test of Dependent Variables

		@3DSP3	@4DPE2	@4DPE3	@4DPE4	@4DPE5	@4DPE9	@5DBP1	@5DBP2	@5DBP3	@5DBP18	@5DBP22
Anti-image Covariance	@3DSP3	,250	,079	-,078	-,128	-,162	-,110	,017	,025	-,110	-,076	,005
	@4DPE2	,079	,272	-,154	-,083	-,096	-,159	-,024	-,107	-,167	-,018	,153
	@4DPE3	-,078	-,154	,244	,058	,074	,182	,024	,174	,130	,048	-,161
	@4DPE4	-,128	-,083	,058	,445	,028	,009	-,148	,030	,073	,066	-,017
	@4DPE5	-,162	-,096	,074	,028	,282	,067	-,056	-,023	,042	,128	-,067
	@4DPE9	-,110	-,159	,182	,009	,067	,401	,070	-,005	,118	,026	-,077
	@5DBP1	,017	-,024	,024	-,148	-,056	,070	,385	-,003	-,080	-,120	-,079
	@5DBP2	,025	-,107	,174	,030	-,023	-,005	-,003	,429	,083	-,061	-,153
	@5DBP3	-,110	-,167	,130	,073	,042	,118	-,080	,083	,273	,006	-,052
	@5DBP18	-,076	-,018	,048	,066	,128	,026	-,120	-,061	,006	,582	-,209
	@5DBP22	,005	,153	-,161	-,017	-,067	-,077	-,079	-,153	-,052	-,209	,487
Anti-image Correlation	@3DSP3	,665[a]	,302	-,314	-,383	-,610	-,348	,056	,076	-,422	-,199	,015
	@4DPE2	,302	,522[a]	-,598	-,237	-,349	-,483	-,075	-,313	-,614	-,046	,421
	@4DPE3	-,314	-,598	,428[a]	,175	,283	,581	,079	,538	,505	,126	-,466
	@4DPE4	-,383	-,237	,175	,804[a]	,078	,021	-,357	,069	,209	,129	-,038

	@4DPE5	-,610	-,349	,283	,078	,731[a]	,200	-,169	-,067	,151	,316	-,180
	@4DPE9	-,348	-,483	,581	,021	,200	,551[a]	,177	-,011	,358	,053	-,174
	@5DBP1	,056	-,075	,079	-,357	-,169	,177	,841[a]	-,007	-,246	-,254	-,183
	@5DBP2	,076	-,313	,538	,069	-,067	-,011	-,007	,641[a]	,242	-,123	-,334
	@5DBP3	-,422	-,614	,505	,209	,151	,358	-,246	,242	,640[a]	,015	-,142
	@5DBP18	-,199	-,046	,126	,129	,316	,053	-,254	-,123	,015	,575[a]	-,392
	@5DBP22	,015	,421	-,466	-,038	-,180	-,174	-,183	-,334	-,142	-,392	,388[a]
a. Measures of Sampling Adequacy(MSA)												

Table 15.47: Anti-Image Matrix of Dependent Variables

The statistics defining the total variance of the included variables *(see table 15.9)* reveal that with eleven variables, three components or factors could be extracted with an Eigen value of more than one. The extracted components account for 71.2 % of the combined cumulative percentage variance.

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	*4,463*	*40,570*	*40,570*	*4,463*	*40,570*	*40,570*	*3,825*	*34,774*	*34,774*
2	*1,735*	*15,772*	*56,342*	*1,735*	*15,772*	*56,342*	*2,234*	*20,306*	*55,079*
3	*1,641*	*14,922*	*71,264*	*1,641*	*14,922*	*71,264*	*1,780*	*16,185*	*71,264*
4	*,706*	*6,416*	*77,679*						
5	*,564*	*5,132*	*82,811*						
6	*,522*	*4,749*	*87,560*						
7	*,487*	*4,430*	*91,990*						
8	*,336*	*3,055*	*95,044*						
9	*,273*	*2,485*	*97,530*						
10	*,188*	*1,707*	*99,236*						
11	*,084*	*,764*	*100,000*						
Extraction Method: Principal Component Analysis.									

Table 15.48: Total Variance of Dependent Variables

The Scree plot shown in *figure 15.8* with the Eigen value on the Y-axis and associated factor on the X-axis reveals that three factors lie above the bend of the curve accounting for the maximum variance. The other factors are loaded almost flat on the curve lying below the bend of the curve justifying the appropriateness of a three-component solution for the dependent variables.

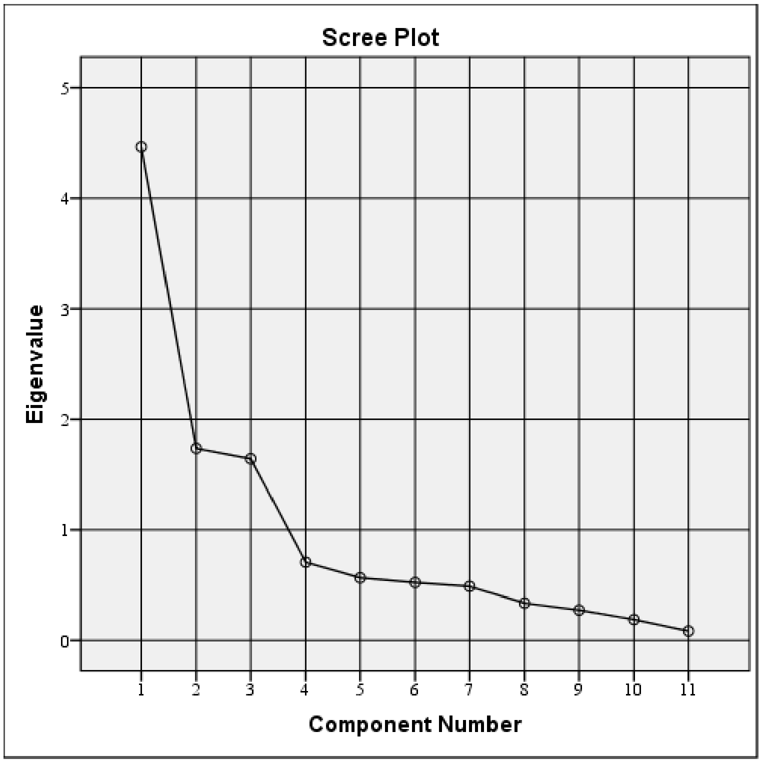


Figure 15.8: Scree Plot of Dependent Variables

Further to factor extraction, the communalities (the amount of variance each variable shares with the remaining included variables) are extracted using the principal component analysis (PCA) method and the results are shown in *table 15.49*. The results indicated that the communalities are significantly high for each variable with the remaining included.

Communalities		
	Initial	Extraction
@3DSP3	*1,000*	*,736*
@4DPE2	*1,000*	*,660*
@4DPE3	*1,000*	*,805*
@4DPE4	*1,000*	*,608*
@4DPE5	*1,000*	*,720*
@4DPE9	*1,000*	*,682*
@5DBP1	*1,000*	*,708*
@5DBP2	*1,000*	*,757*
@5DBP3	*1,000*	*,680*
@5DBP18	*1,000*	*,718*
@5DBP22	*1,000*	*,764*
Extraction Method: Principal Component Analysis.		

Table 15.49: Communalities of Dependent Variables

The component matrix is extracted using principal component analysis method for all the dependent variables. The unrotated factor loading component matrix results are shown in *table 15.50* and indicate all the eleven variables are significantly correlated (more than 0.5) with either one of the three components extracted. This supports the interpretation made from Eigen values.

Component Matrix[a]			
	Component		
	1	2	3
@3DSP3	,791		
@4DPE2	,700		
@4DPE3	-,541	,516	
@4DPE4	,749		
@4DPE5	,818		
@4DPE9	,540	-,523	
@5DBP1	,756		
@5DBP2			,667
@5DBP3	,787		
@5DBP18		,563	,575
@5DBP22		,762	
Extraction Method: Principal Component Analysis.			
a. 3 components extracted.			

Table 15.50: Component Matrix of Dependent Variables

With three component extracted, the factor analysis solution has to be rotated. The rotation does not alter the underlying solution, but rather illustrates the pattern of loadings for ease of interpretation. The researcher adapted the Varimax and Kaiser Normalisation technique for rotation and the results are shown in *table 15.51*. The main loadings on component 1 are @3DSP3, @4DPE2, @4DPE4, @4DPE5, @5DBP1, @5DBP3, on component 2 @4DPE3, @4DPE9, @5DBP2 and on component 3 @5DBP18, @5DBP22.

Rotated Component Matrix[a]			
	Component		
	1	2	3
@3DSP3	,840		
@4DPE2	,751		
@4DPE3		-,879	
@4DPE4	,762		
@4DPE5	,824		
@4DPE9		,779	
@5DBP1	,731		
@5DBP2		,821	
@5DBP3	,809		
@5DBP18			,828
@5DBP22			,864
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			

a. Rotation converged in 4 iterations.

Table 15.51: Rotated Component Matrix of Dependent Variables

With an Eigen value of more than one on three components and strong factor loadings on three components for all the included variables, three surrogate variables can be deduced representing the eleven variables. The research henceforth introduces three new surrogate variables ***'@DPPS1'*** (representing @3DSP3, @4DPE2, @4DPE4, @4DPE5, @5DBP1, @5DBP3), ***'@DPPS2'*** (representing @4DPE3, @4DPE9, @5DBP2) and ***'@DPPS3'*** (representing @5DBP18, @5DBP22) representing all the dependent variables observed in this research.

16 Hypothesis Test and Discussion

16.1 Hypothesis Testing of Front End Planning/Start-Up Plan

1. *The Critical Success Factor Front End Planning/Start-up Plan is not influencing the Project performance.*
    - 1.1 *The Critical Success Factor Front End Planning/Start-up Plan is not influencing the surrogate variable @DPPS1.*
    - 1.2 *The Critical Success Factor Front End Planning/Start-up Plan is not influencing the surrogate variable @DPPS2.*
    - 1.3 *The Critical Success Factor Front End Planning/Start-up Plan is not influencing the surrogate variable @DPPS3.*

16.1.1 Hypothesis Test of Front End Planning/Start-up Plan and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in *chapter 15* the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of front-end planning/start-up plan on project performance.

Four independent variables accuracy of policies governing budget/schedule estimates (@3ISP2), encouragement from organization for start-up plan formulation (@3ISP4), competency of the teams/team members who formulate the start-up plan (@3ISP5) and level of start-up plan alignment for the projects executed or being executed (@3ISP6) are used as predictors to investigate their influence on the surrogate variable @DPPS1. However, the hypothesis test shall use the surrogate variable '@3ISPS1' representing all the independent variables measured for predicting front end planning/Start-up plan based on the results of the statistical dimension reduction techniques in *chapter 15*.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.1*.

Correlations			
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @3ISPS1
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	*1*	*-,283*
	Sig. (2-tailed)		*,203*
	N	*22*	*22*
Regression Factor Score for Surrogate Variable @3ISPS1	Pearson Correlation	*-,283*	*1*
	Sig. (2-tailed)	*,203*	
	N	*22*	*22*

Table 16.1: Pearson's Correlation Matrix for Front End Planning/Start-up Plan and @DPPS1

According to the Pearson's correlation matrix, the surrogate independent variable @3ISPS1 showed no linear relationship with the depending surrogate variable @ DPPS1. The degree of measure of linear relationship yielded a negative correlation coefficient r = -0.283 but at a significance level of 0.203 (2-tailed). With the correlation coefficient close to zero, the strength of the relationship is weak but with a p-value greater than 0.05 (Sig. =0.203, 2-tailed). Based on the analysis, contrary to the expectation of the researcher, the hypothesis *'The Critical Success Factor Front End Planning/Start-up Plan is not influencing the surrogate variable @DPPS1'* is accepted.

16.1.2 Discussion on Hypothesis Test of Front End Planning/Start-up Plan and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variable using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

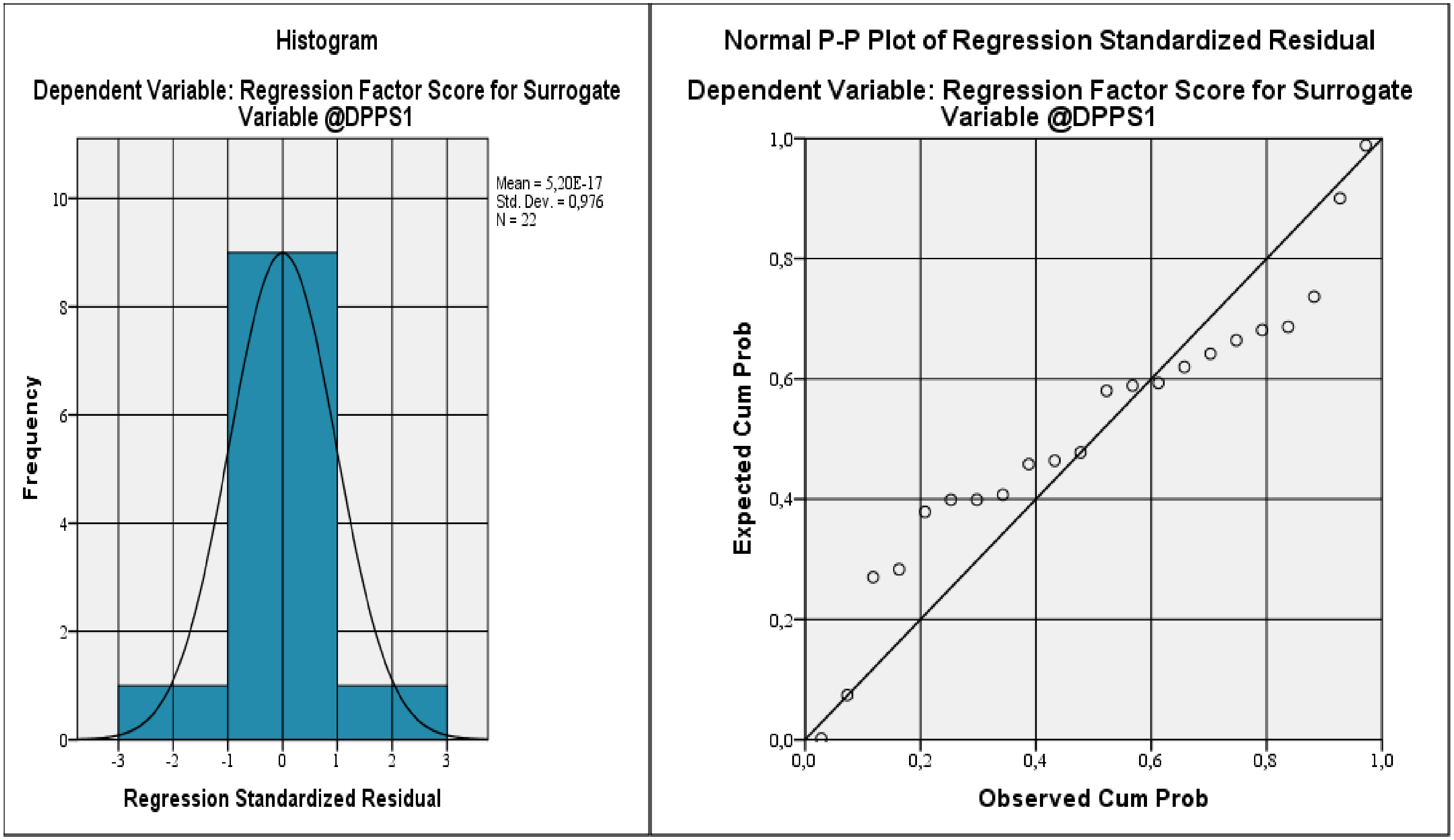


Figure 16.1: Normal Distribution Chart and Normal P-P Plot of Surrogate Variable @ DPPS1

The regression model summary shown in *table 16.2* indicates that a proportion of the order 0.08 (8 %) (Variance or R-square or coefficient of determination) in the dependent surrogate variable @DPPS1 can be predicted using independent surrogate variable @3ISPS1. With only one variable in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.034) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be negative (B = -.283) and the Standardized Beta (β) indicated a coefficient of -0.283 for a statistical t-value of -1.317. This means that each unit of @DPPS1 is associated with a score of -0.283 units in @3ISPS1 at a significance level 0.203. The p-value (Sig. = 0.203, 2-tailed) associated with F-Value or F-Statistic (calculated mathematically by dividing the regression mean square by the residual mean square) was found to be more than the alpha or significance level 0.05. This indicates that the independent surrogate variable @3ISPS1 is not statistically and significantly associated with the dependent surrogate variable. In other words, the included set of independent surrogate variables does not reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,283*[a]	*,080*	*,034*	*,98294415*	*,080*	*1,735*	*1*	*20*	*,203*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @3ISPS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*1,676*	*1*	*1,676*	*1,735*	*,203*[b]
	Residual	*19,324*	*20*	*,966*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @3ISPS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-1,135E-015*	*,210*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @3ISPS1	*-,283*	*,214*	*-,283*	*-1,317*	*,203*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

Table 16.2: Regression Analysis results for Hypothesis 1.1

16.1.3 Hypothesis Test of Front End Planning/Start-up Plan and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of front-end planning/start-up plan on project performance.

Four independent variables accuracy of policies governing budget/schedule estimates (@3ISP2), encouragement from organisation for start-up plan formulation (@3ISP4), competency of the teams/team members who formulate the start-up plan (@3ISP5) and level of start-up plan alignment for the projects executed or being executed (@3ISP6) are used as predictors to investigate their influence on the surrogate variable @DPPS2. However, the hypothesis test shall use the surrogate variable '@3ISPS1' representing all the independent variables measured for predicting front end planning/Start-up plan based on the results of the statistical dimension reduction techniques in *chapter 15*.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.3*.

Correlations			
		Regression Factor Score for Surrogate Variable @3ISPS1	Regression Factor Score for Surrogate Variable @DPPS2
Regression Factor Score for Surrogate Variable @3ISPS1	Pearson Correlation	*1*	*,175*
	Sig. (2-tailed)		*,437*
	N	*22*	*22*
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	*,175*	*1*
	Sig. (2-tailed)	*,437*	
	N	*22*	*22*

Table 16.3: Pearson's Correlation Matrix for Front End Planning/Start-up Plan and @DPPS2

According to the Pearson's correlation matrix, the surrogate independent variable @3ISPS1 showed a positive linear relationship with the depending surrogate variable @ DPPS2. The degree of measure of linear relationship yielded a negative correlation coefficient r = 0.175 but at a significance level of 0.437 (2-tailed). With the correlation coefficient close to zero, the strength of the relationship is weak but with a p-value greater than 0.05 (Sig. =0.437, 2-tailed). Based on the analysis, contrary to the expectation of the researcher, the hypothesis *'The Critical Success Factor Front End Planning/Start-up Plan is not influencing the surrogate variable @DPPS2'* is accepted.

16.1.4 Discussion on Hypothesis Test of Front End Planning/Start-up Plan and @DPPS2

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variable using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart normal P-P plot of regression in *figure 16.2*.

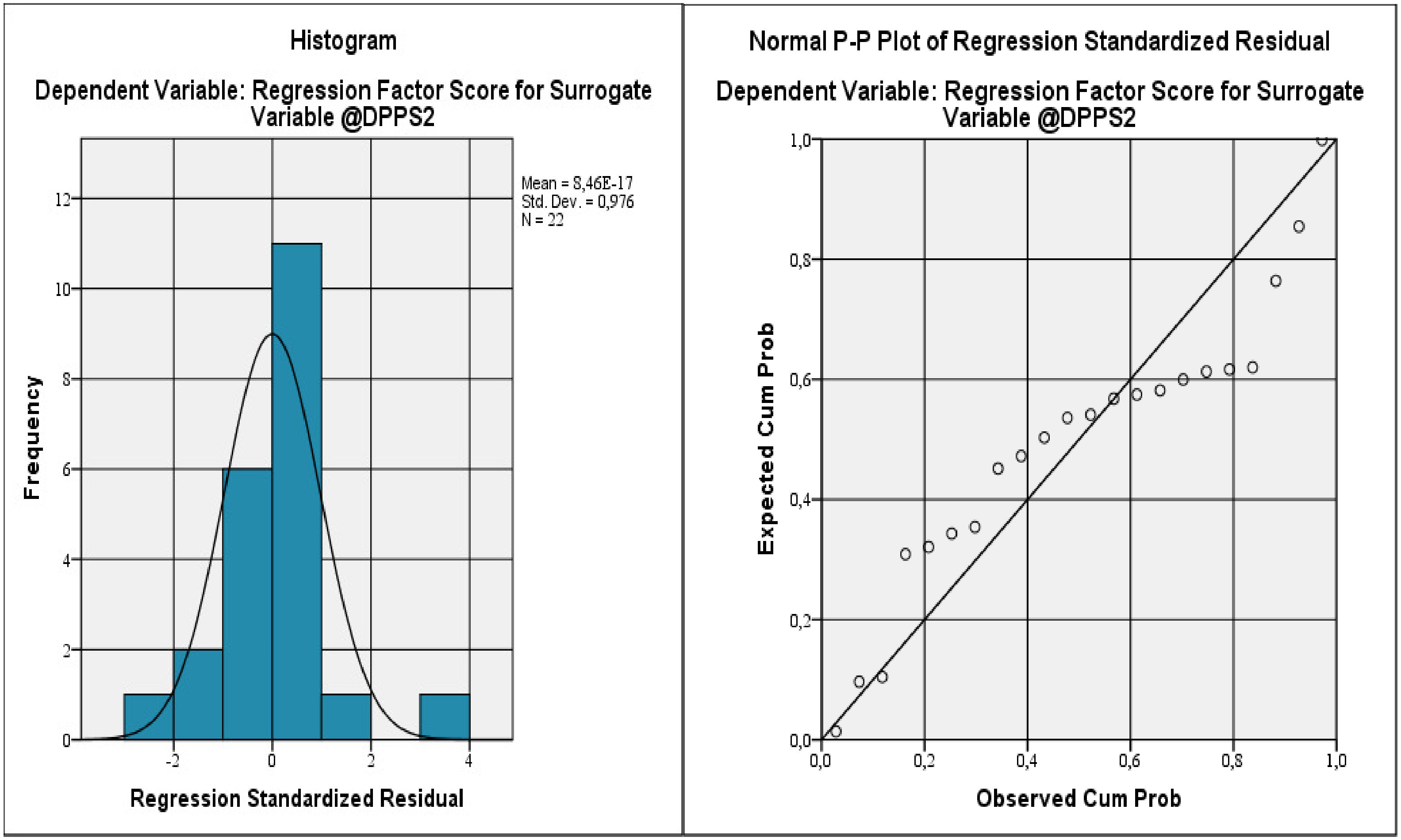


Figure 16.2: Normal Distribution Chart and Normal P-P Plot of Surrogate Variable @ DPPS2

The regression model summary shown in *table 16.4* indicates that a proportion of the order 0.03 (3 %) (Variance or R-square or coefficient of determination) in the dependent surrogate variable @DPPS2 can be predicted using independent surrogate variable @3ISPS1. With only one variable in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.018) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be positive (B = 0.175) and the Standardized Beta (β) indicated a coefficient of 0.175 for a statistical t-value of 0.793. This means that each unit of @DPPS2 is associated with a score of 0.175 units in @3ISPS1 at a significance level 0.437. The p-value (Sig. = 0.437, 2-tailed) associated with F-Value or F-Statistic (calculated mathematically by dividing the regression mean square by the residual mean square) was found to be more than the alpha or significance level 0.05. This indicates that the independent surrogate variable @3ISPS1 is not statistically and significantly associated with the dependent surrogate variable. In other words, the included set of independent surrogate variables does not reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,175*[a]	*,030*	*-,018*	*1,00895212*	*,030*	*,629*	*1*	*20*	*,437*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @3ISPS1
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*,640*	*1*	*,640*	*,629*	*,437*[b]
	Residual	*20,360*	*20*	*1,018*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @3ISPS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*9,915E-016*	*,215*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @3ISPS1	*,175*	*,220*	*,175*	*,793*	*,437*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

Table 16.4: Regression Analysis results for Hypothesis 1.2

16.1.5 Hypothesis Test of Front End Planning/Start-up Plan and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of front-end planning/start-up plan on project performance.

Four independent variables accuracy of policies governing budget/schedule estimates (@3ISP2), encouragement from organization for start-up plan formulation (@3ISP4), competency of the teams/team members who formulate the start-up plan (@3ISP5) and level of start-up plan alignment for the projects executed or being executed (@3ISP6) are used as predictors to investigate their influence on the surrogate variable @DPPS3. However, the hypothesis test shall use the surrogate variable '@3ISPS1' representing all the independent variables measured for predicting front end planning/Start-up plan based on the results of the statistical dimension reduction techniques in *chapter 15*.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.5*.

Correlations			
		Regression Factor Score for Surrogate Variable @3ISPS1	Regression Factor Score for Surrogate Variable @DPPS3
Regression Factor Score for Surrogate Variable @3ISPS1	Pearson Correlation	*1*	*-,534**
	Sig. (2-tailed)		*,010*
	N	*22*	*22*
Regression Factor Score for Surrogate Variable @DPPS3	Pearson Correlation	*-,534**	*1*
	Sig. (2-tailed)	*,010*	
	N	*22*	*22*
*. Correlation is significant at the 0.05 level (2-tailed).			

Table 16.5 Pearson's Correlation Matrix for Front End Planning/Start-up Plan and @DPPS3

According to the Pearson's correlation matrix, the surrogate independent variable @3ISPS1 showed a positive and significant linear relationship with the depending surrogate variable @ DPPS3. The degree of measure of linear relationship yielded a negative correlation coefficient r = -0.534 at a significance level of 0.01 (Sig. =0.01, 2-tailed). Based on the analysis, as expected by the researcher, the hypothesis *'The Critical Success Factor Front End Planning/Start-up Plan is not influencing the surrogate variable @DPPS3'* is rejected.

16.1.6 Discussion on Hypothesis Test of Front End Planning/Start-up Plan and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variable using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

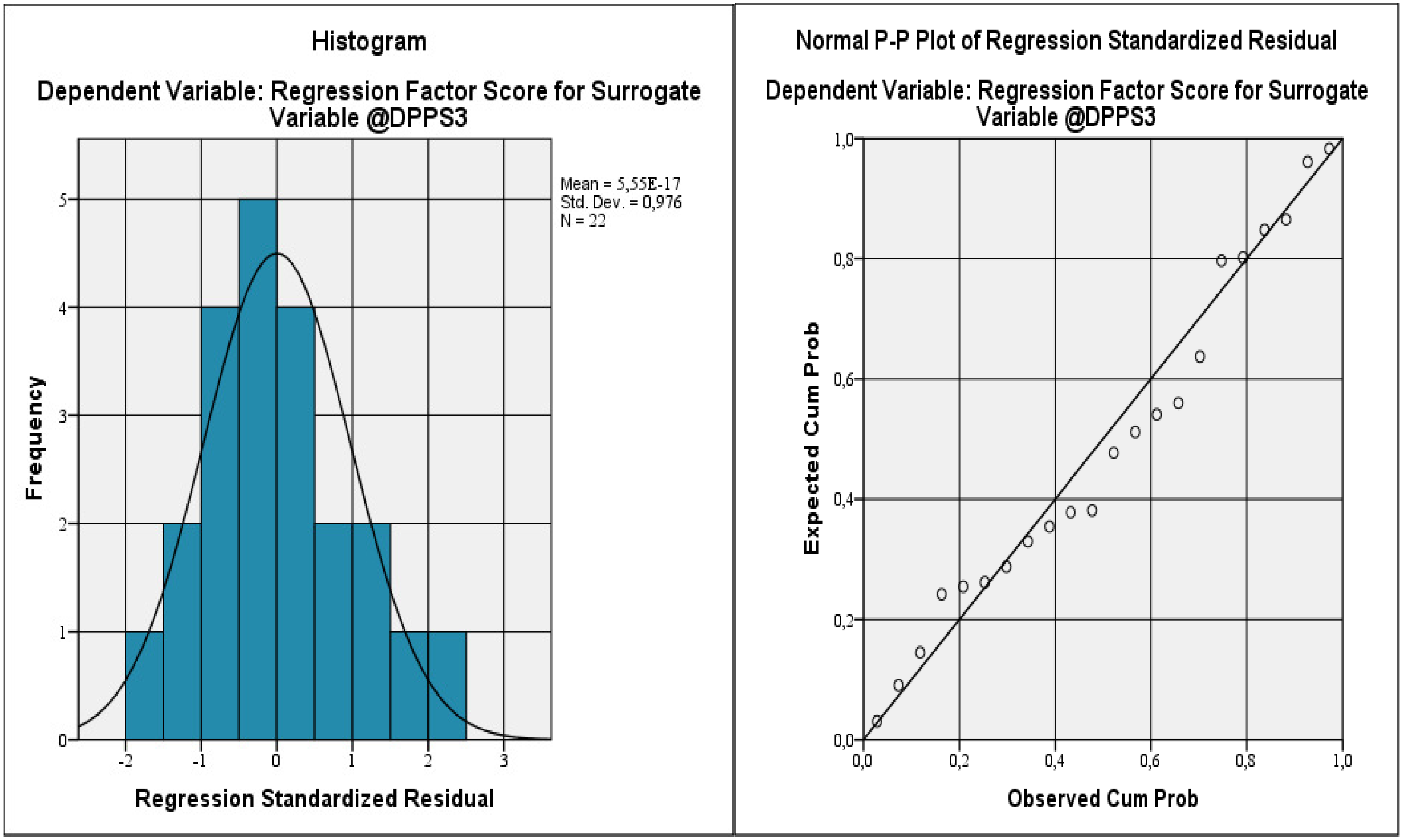


Figure 16.3: Normal Distribution Chart and Normal P-P Plot of Surrogate Variable @ DPPS3

The regression model summary shown in table *16.6* indicates that a proportion of the order 0.534 (53.4 %) (Variance or R-square or coefficient of determination) in the dependent surrogate variable @DPPS3 can be predicted using independent surrogate variable @3ISPS1. With only one variable in the analysis, the more honest value of coefficient of determination, adjusted R-square, yielded 0.250. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be negative (B = -0.534) and the Standardized Beta (β) indicated a coefficient of -0.534 for a statistical t-value of -2.82. This means that each unit of @DPPS3 is associated with a score of -0.534 units in @3ISPS1 at a significance level 0.01. The p-value (Sig. = 0.01, 2-tailed) associated with F-Value or F-Statistic (calculated mathematically by dividing the regression mean square by the residual mean square) was found to be less than the alpha or significance level 0.05. This indicates that the independent surrogate variable @3ISPS1 is statistically and significantly associated with the dependent surrogate variable. In other words, the included set of independent surrogate variables reliably predicts the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,534*[a]	*,286*	*,250*	*,86614387*	*,286*	*7,992*	*1*	*20*	*,010*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @3ISPS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*5,996*	*1*	*5,996*	*7,992*	*,010*[b]
	Residual	*15,004*	*20*	*,750*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @3ISPS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*2,212E-016*	*,185*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @3ISPS1	*-,534*	*,189*	*-,534*	*-2,827*	*,010*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

Table 16.6: Regression Analysis results for Hypothesis 1.3

16.2 Hypothesis Testing of Project Execution

2. *The Critical Success Factor Project Execution is not influencing the Project performance.*
   2.1 *The Critical Success Factor Project Execution is not influencing the surrogate variable @DPPS1.*

2.2 The Critical Success Factor Project Execution is not influencing the surrogate variable @DPPS2.

2.3 The Critical Success Factor Project Execution is not influencing the surrogate variable @DPPS3.

16.2.1 Hypothesis Test of Project Execution and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in *chapter 15* the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of project execution on project performance.

Five independent variables: Mobilization of Startup resources on time (@4IPE1), Level of integration between the Project disciplines (E, P and C) (@4IPE6), Level of integration between the engineering disciplines (@4IPE7), Effectiveness of Information Technology applications to monitor progress made during project execution (@4IPE10), Timeliness of the dependent disciplines for information (@4IPE13) are used as predictors to investigate their influence on the surrogate variable @DPPS1. However, the hypothesis test shall use the surrogate variables '@4IPES1' (representing @4IPE6 and @4IPE7), '@4IPES2' (representing @4IPE1 and @4IPE13) and '@4IPES3' (representing @4IPE10) representing all the independent variables measured for predicting project execution based on the results of the statistical dimension reduction techniques in *chapter 15*.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.7*.

Correlations					
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @4IPES1	Regression Factor Score for Surrogate Variable @4IPES2	Regression Factor Score for Surrogate Variable @4IPES3
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	1	,088	-,114	,153
	Sig. (2-tailed)		,696	,613	,496
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @4IPES1	Pearson Correlation	,088	1	,000	,000
	Sig. (2-tailed)	,696		1,000	1,000
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @4IPES2	Pearson Correlation	-,114	,000	1	,000
	Sig. (2-tailed)	,613	1,000		1,000
	N	22	22	22	22

Regression Factor Score for Surrogate Variable @4IPES3	Pearson Correlation	*,153*	*,000*	*,000*	*1*
	Sig. (2-tailed)	*,496*	*1,000*	*1,000*	
	N	*22*	*22*	*22*	*22*

Table 16.7 Pearson's Correlation Matrix for Project Execution and @DPPS1

According to the Pearson's correlation matrix, the surrogate independent variables @4IPES1, @4IPES2 and @4IPES3 showed no significant relationship with the dependent surrogate variable @ DPPS1. The degree of measure of linear relationship with @ DPPS1 yielded a Pearson's correlation coefficient of 0.088, -0.114, 0.153 (2-tailed) respectively but with a p-value greater than 0.05 (Sig. =0.696, 0.613, 0.496 respectively, 2-tailed). Based on the analysis, the hypothesis *'The Critical Success Project Execution is not influencing the surrogate variable @DPPS1'* is accepted.

16.2.2 Discussion on Hypothesis Test of Project Execution and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

The regression model summary shown in *table 16.8* indicates that a proportion of the order 0.210 (21 %) variance in the dependent surrogate variable @DPPS1 can be predicted using independent surrogate variables @4IPES1, @4IPES2 and @4IPES3. With three variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.115) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.088, -0.114, and 0.153 with statistical t-values of 0.383, -0.495, and 0.664 for @4IPES1, @4IPES2 and @4IPES3 respectively. This means that each unit of @DPPS1 is associated with a score of 0.088 units in @4IPES1, -0.114 units in @4IPES2 and 0.153 units in @4IPES3 at a significance level higher than 0.05. This indicates that the independent surrogate variables @4IPES1, @4IPES2, @4IPES3 are not statistically and significantly associated with the dependent surrogate variable. In other words, the included set of independent surrogate variables does not reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,210*[a]	*,044*	*-,115*	*1,05597176*	*,044*	*,278*	*3*	*18*	*,841*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @4IPES3, Regression Factor Score for Surrogate Variable @4IPES2, Regression Factor Score for Surrogate Variable @4IPES1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*,929*	*3*	*,310*	*,278*	*,841*[b]
	Residual	*20,071*	*18*	*1,115*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @4IPES3, Regression Factor Score for Surrogate Variable @4IPES2, Regression Factor Score for Surrogate Variable @4IPES1

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-1,325E-015*	*,225*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @4IPES1	*,088*	*,230*	*,088*	*,383*	*,706*
	Regression Factor Score for Surrogate Variable @4IPES2	*-,114*	*,230*	*-,114*	*-,495*	*,627*
	Regression Factor Score for Surrogate Variable @4IPES3	*,153*	*,230*	*,153*	*,664*	*,515*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1						

Table 16.8: Regression Analysis results for Hypothesis 2.1

16.2.3 Hypothesis Test of Project Execution and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of project execution on project performance.

Five independent variables: Mobilization of Startup resources on time (@4IPE1), Level of integration between the Project disciplines (E, P and C) (@4IPE6), Level of integration between the engineering disciplines (@4IPE7), Effectiveness of Information Technology applications to monitor progress made during project execution (@4IPE10), Timeliness of the dependent disciplines for information (@4IPE13) are used as predictors to investigate their influence on the surrogate variable @DPPS2. However, the hypothesis test shall use the surrogate variables '@4IPES1' (representing @4IPE6 and @4IPE7), '@4IPES2' (representing @4IPE1 and @4IPE13) and '@4IPES3' (representing @4IPE10) representing all the independent variables measured for predicting project execution based on the results of the statistical dimension reduction techniques in *chapter 15*.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.9*.

Correlations					
		Regression Factor Score for Surrogate Variable @DPPS2	Regression Factor Score for Surrogate Variable @4IPES1	Regression Factor Score for Surrogate Variable @4IPES2	Regression Factor Score for Surrogate Variable @4IPES3
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	*1*	*,593***	*-,288*	*,306*
	Sig. (2-tailed)		*,004*	*,194*	*,166*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for	Pearson Correlation	*,593***	*1*	*,000*	*,000*

Surrogate Variable @4IPES1	Sig. (2-tailed)	,004		1,000	1,000
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @4IPES2	Pearson Correlation	-,288	,000	1	,000
	Sig. (2-tailed)	,194	1,000		1,000
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @4IPES3	Pearson Correlation	,306	,000	,000	1
	Sig. (2-tailed)	,166	1,000	1,000	
	N	22	22	22	22
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 16.9: Pearson's Correlation Matrix for Project Execution and @DPPS2

According to the Pearson's correlation matrix, the one out of three surrogate independent variables @4IPES1, @4IPES2 and @4IPES3 showed significant relationship with the dependent surrogate variable @ DPPS2. The degree of measure of linear relationship between @DPPS2 and @4IPES1 yielded a coefficient of r = 0.593 (2-tailed) with a p-value less than 0.05 (Sig. = 0.004, 2-tailed). Hence, the hypothesis *'The Critical Success Project Execution is not influencing the surrogate variable @DPPS2'* is rejected.

16.2.4 Discussion on Hypothesis Test of Project Execution and @DPPS2

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.2*.

The regression model summary shown in *table 16.10* indicates that a proportion of the order 0.527 (52.7 %) variance in the dependent surrogate variable @DPPS2 can be predicted using independent surrogate variables @4IPES1, @4IPES2 and @4IPES3. With three variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.449) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.593, -0.288, and 0.306 with statistical t-values of 3.657, -1.776 and 1.887 for @4IPES1, @4IPES2 and @4IPES3 respectively. This means that each unit of @DPPS2 is associated with a score of 0.593 units in @4IPES1 at a significance level 0.02, -0.288 units in @4IPES2 at a significance level 0.09 and 0.306 units in @4IPES3 at a significance level 0.075. One out of three independent surrogate variables is statistically and significantly associated with the dependent surrogate variable at a significance level less than 0.05 and remaining two at a significance level 0.01. In other words, the included set of independent surrogate variables consists of at least one predictor that reliably predicts the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,726[a]	,527	,449	,74256202	,527	6,695	3	18	,003
a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @4IPES3, Regression Factor Score for Surrogate Variable @4IPES2, Regression Factor Score for Surrogate Variable @4IPES1									
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2									
ANOVA[a]									

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*11,075*	*3*	*3,692*	*6,695*	*,003*[b]
	Residual	*9,925*	*18*	*,551*		
	Total	*21,000*	*21*			
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2						
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @4IPES3, Regression Factor Score for Surrogate Variable @4IPES2, Regression Factor Score for Surrogate Variable @4IPES1						

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*1,428E-015*	*,158*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @4IPES1	*,593*	*,162*	*,593*	*3,657*	*,002*
	Regression Factor Score for Surrogate Variable @4IPES2	*-,288*	*,162*	*-,288*	*-1,776*	*,093*
	Regression Factor Score for Surrogate Variable @4IPES3	*,306*	*,162*	*,306*	*1,887*	*,075*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2						

Table 16.10: Regression Analysis results for Hypothesis 2.2

16.2.5 Hypothesis Test of Project Execution and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of front-end planning/start-up plan on project performance.

Five independent variables: Mobilisation of Startup resources on time (@4IPE1), Level of integration between the Project disciplines (E, P and C) (@4IPE6), Level of integration between the engineering disciplines (@4IPE7), Effectiveness of Information Technology applications to monitor progress made during project execution (@4IPE10), Timeliness of the dependent disciplines for information (@4IPE13) are used as predictors to investigate their influence on the surrogate variable @DPPS3. However, the hypothesis test shall use the surrogate variables '@4IPES1' (representing @4IPE6 and @4IPE7), '@4IPES2' (representing @4IPE1 and @4IPE13) and '@4IPES3' (representing @4IPE10) representing all the independent variables measured for predicting project execution based on the results of the statistical dimension reduction techniques in *chapter 15*.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.11*.

Correlations					
		Regression Factor Score for Surrogate Variable @DPPS3	Regression Factor Score for Surrogate Variable @4IPES1	Regression Factor Score for Surrogate Variable @4IPES2	Regression Factor Score for Surrogate Variable @4IPES3
Regression Factor Score for Surrogate Variable @DPPS3	Pearson Correlation	*1*	*-,493**	*-,384*	*-,042*
	Sig. (2-tailed)		*,020*	*,077*	*,851*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @4IPES1	Pearson Correlation	*-,493**	*1*	*,000*	*,000*
	Sig. (2-tailed)	*,020*		*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @4IPES2	Pearson Correlation	*-,384*	*,000*	*1*	*,000*
	Sig. (2-tailed)	*,077*	*1,000*		*1,000*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @4IPES3	Pearson Correlation	*-,042*	*,000*	*,000*	*1*
	Sig. (2-tailed)	*,851*	*1,000*	*1,000*	
	N	*22*	*22*	*22*	*22*
*. Correlation is significant at the 0.05 level (2-tailed).					

Table 16.11: Pearson's Correlation Matrix for Project Execution and @DPPS3

According to the Pearson's correlation matrix, one out of three surrogate independent variables @4IPES1, @4IPES2 and @4IPES3 showed significant negative relationship with the dependent surrogate variable @ DPPS3. The degree of measure of linear relationship between @DPPS3 and @4IPES1 yielded a coefficient of r = -0.493 (2-tailed) with a p-value less than 0.05 (Sig. = 0.02, 2-tailed). Hence, the hypothesis *'The Critical Success Project Execution is not influencing the surrogate variable @DPPS3'* is rejected.

16.2.6 Discussion on Hypothesis Test of Project Execution and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

The regression model summary shown in *table 16.12* indicates a correlation R = 0.627 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.393 (39.3 %) in the dependent surrogate variable @DPPS3 can be predicted using independent surrogate variables @4IPES1, @4IPES2 and @4IPES3. With three variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.291) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.493, -0.384, and -0.042 with statistical t-values of -2.68, -2.09, -0.231 for @4IPES1, @4IPES2 and @4IPES3 respectively. This means that each unit of @DPPS3 is associated with a score of -0.493 units in @4IPES1 at a significance level 0.015, -0. 384 units in @4IPES2 at a significance level 0.05 and -0. 042 units in @4IPES3 at a significance level 0.820. One out of three independent surrogate variables is statistically and significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of at least one predictor that reliably predicts the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,627[a]*	*,393*	*,291*	*,84182385*	*,393*	*3,878*	*3*	*18*	*,027*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @4IPES3, Regression Factor Score for Surrogate Variable @4IPES2, Regression Factor Score for Surrogate Variable @4IPES1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*8,244*	*3*	*2,748*	*3,878*	*,027[b]*
	Residual	*12,756*	*18*	*,709*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @4IPES3, Regression Factor Score for Surrogate Variable @4IPES2, Regression Factor Score for Surrogate Variable @4IPES1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-3,465E-016*	*,179*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @4IPES1	*-,493*	*,184*	*-,493*	*-2,684*	*,015*
	Regression Factor Score for Surrogate Variable @4IPES2	*-,384*	*,184*	*-,384*	*-2,092*	*,051*
	Regression Factor Score for Surrogate Variable @4IPES3	*-,042*	*,184*	*-,042*	*-,231*	*,820*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

Table 16.12: Regression Analysis results for Hypothesis 2.3

16.3 Hypothesis Testing of Best Practices

3. *The Critical Success Factor Best Practice is not influencing the Project performance.*
   - 3.1 *The Critical Success Factor Best Practices is not influencing the surrogate variable @DPPS1.*
   - 3.2 *The Critical Success Factor Best Practices is not influencing the surrogate variable @DPPS2.*
   - 3.3 *The Critical Success Factor Best Practices is not influencing the surrogate variable @DPPS3.*

16.3.1 Hypothesis Test of Best Practices and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in *chapter 15* the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of best practices on project performance.

Seven surrogate variables @5IBPS1 (representing @5IBP5, @5IBP12, @5IBP14, @5IBP15, @5IBP16, @5IBP21), @5IBPS2 (representing @5IBP8, @5IBP9, @5IBP10), @5IBPS3 (representing @5IBP4, @5IBP19, @5IBP20), @5IBPS4 (representing @5IBP6, @5IBP7, @5IBP11, @5IBP13), @5IBPS5 (representing @5IBP24, @5IBP25), @5IBPS6 (representing @5IBP23), @5IBPS7 (representing @5IBP17, @5IBP27) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of best practices on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.13.*

Correlations									
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @5IBPS1	Regression Factor Score for Surrogate Variable @5IBPS2	Regression Factor Score for Surrogate Variable @5IBPS3	Regression Factor Score for Surrogate Variable @5IBPS4	Regression Factor Score for Surrogate Variable @5IBPS5	Regression Factor Score for Surrogate Variable @5IBPS6	Regression Factor Score for Surrogate Variable @5IBPS7
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	*1*	*,113*	*-,028*	*-,107*	*,030*	*,082*	*,043*	*-,197*
	Sig. (2-tailed)		*,617*	*,901*	*,635*	*,894*	*,718*	*,849*	*,380*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS1	Pearson Correlation	*,113*	*1*	*,000*	*,000*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,617*		*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS2	Pearson Correlation	*-,028*	*,000*	*1*	*,000*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,901*	*1,000*		*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*

Regression Factor Score for Surrogate Variable @5IBPS3	Pearson Correlation	*-,107*	*,000*	*,000*	*1*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,635*	*1,000*	*1,000*		*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS4	Pearson Correlation	*,030*	*,000*	*,000*	*,000*	*1*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,894*	*1,000*	*1,000*	*1,000*		*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS5	Pearson Correlation	*,082*	*,000*	*,000*	*,000*	*,000*	*1*	*,000*	*,000*
	Sig. (2-tailed)	*,718*	*1,000*	*1,000*	*1,000*	*1,000*		*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS6	Pearson Correlation	*,043*	*,000*	*,000*	*,000*	*,000*	*,000*	*1*	*,000*
	Sig. (2-tailed)	*,849*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*		*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS7	Pearson Correlation	*-,197*	*,000*	*,000*	*,000*	*,000*	*,000*	*,000*	*1*
	Sig. (2-tailed)	*,380*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*

Table 16.13: Pearson's Correlation Matrix for Best Practices and @DPPS1

According to the Pearson's correlation matrix, the seven surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS1. Hence, the hypothesis *'The Critical Success Best Practices is not influencing the surrogate variable @DPPS1'* is accepted.

16.3.2 Discussion on Hypothesis Test of Best Practices and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

The regression model summary shown in *table 16.14* indicates a correlation R = 0.271 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.073 (7.3 %) in the dependent surrogate variable @DPPS1 can be predicted using the seven independent surrogate variables. With seven variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.390) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.113, -0.028, -0.107, 0.030, 0.082, 0.043 and -0.197 for @5IBPS1, @5IBPS2, @5IBPS3, @5IBPS4, @5IBPS5, @5IBPS6 and @5IBPS7 respectively. The seven independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,271[a]	,073	-,390	1,17905398	,073	,158	7	14	,990

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @5IBPS7, Regression Factor Score for Surrogate Variable @5IBPS6, Regression Factor Score for Surrogate Variable @5IBPS5, Regression Factor Score for Surrogate Variable @5IBPS4, Regression Factor Score for Surrogate Variable @5IBPS3, Regression Factor Score for Surrogate Variable @5IBPS2, Regression Factor Score for Surrogate Variable @5IBPS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1,538	7	,220	,158	,990[b]
	Residual	19,462	14	1,390		
	Total	21,000	21			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @5IBPS7, Regression Factor Score for Surrogate Variable @5IBPS6, Regression Factor Score for Surrogate Variable @5IBPS5, Regression Factor Score for Surrogate Variable @5IBPS4, Regression Factor Score for Surrogate Variable @5IBPS3, Regression Factor Score for Surrogate Variable @5IBPS2, Regression Factor Score for Surrogate Variable @5IBPS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1,407E-015	,251		,000	1,000
	Regression Factor Score for Surrogate Variable @5IBPS1	,113	,257	,113	,439	,667
	Regression Factor Score for Surrogate Variable @5IBPS2	-,028	,257	-,028	-,109	,915
	Regression Factor Score for Surrogate Variable @5IBPS3	-,107	,257	-,107	-,417	,683
	Regression Factor Score for Surrogate Variable @5IBPS4	,030	,257	,030	,117	,909
	Regression Factor Score for Surrogate Variable @5IBPS5	,082	,257	,082	,317	,756

	Regression Factor Score for Surrogate Variable @5IBPS6	*,043*	*,257*	*,043*	*,168*	*,869*
	Regression Factor Score for Surrogate Variable @5IBPS7	*-,197*	*,257*	*-,197*	*-,765*	*,457*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1						

Table 16.14: Regression Analysis results for Hypothesis 3.1

16.3.3 Hypothesis Test of Best Practices and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of best practices on project performance.

Seven surrogate variables @5IBPS1 (representing @5IBP5, @5IBP12, @5IBP14, @5IBP15, @5IBP16, @5IBP21), @5IBPS2 (representing @5IBP8, @5IBP9, @5IBP10), @5IBPS3 (representing @5IBP4, @5IBP19, @5IBP20), @5IBPS4 (representing @5IBP6, @5IBP7, @5IBP11, @5IBP13), @5IBPS5 (representing @5IBP24, @5IBP25), @5IBPS6 (representing @5IBP23), @5IBPS7 (representing @5IBP17, @5IBP27) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of best practices on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.15*.

Correlations									
		Regression Factor Score for Surrogate Variable @DPPS2	Regression Factor Score for Surrogate Variable @5IBPS1	Regression Factor Score for Surrogate Variable @5IBPS2	Regression Factor Score for Surrogate Variable @5IBPS3	Regression Factor Score for Surrogate Variable @5IBPS4	Regression Factor Score for Surrogate Variable @5IBPS5	Regression Factor Score for Surrogate Variable @5IBPS6	Regression Factor Score for Surrogate Variable @5IBPS7
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	*1*	*,147*	*-,005*	*,176*	*,017*	*,071*	*-,243*	*-,130*
	Sig. (2-tailed)		*,514*	*,981*	*,432*	*,940*	*,752*	*,276*	*,565*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS1	Pearson Correlation	*,147*	*1*	*,000*	*,000*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,514*		*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*

Regression Factor Score for Surrogate Variable @5IBPS2	Pearson Correlation	-,005	,000	1	,000	,000	,000	,000	,000
	Sig. (2-tailed)	,981	1,000		1,000	1,000	1,000	1,000	1,000
	N	22	22	22	22	22	22	22	22
Regression Factor Score for Surrogate Variable @5IBPS3	Pearson Correlation	,176	,000	,000	1	,000	,000	,000	,000
	Sig. (2-tailed)	,432	1,000	1,000		1,000	1,000	1,000	1,000
	N	22	22	22	22	22	22	22	22
Regression Factor Score for Surrogate Variable @5IBPS4	Pearson Correlation	,017	,000	,000	,000	1	,000	,000	,000
	Sig. (2-tailed)	,940	1,000	1,000	1,000		1,000	1,000	1,000
	N	22	22	22	22	22	22	22	22
Regression Factor Score for Surrogate Variable @5IBPS5	Pearson Correlation	,071	,000	,000	,000	,000	1	,000	,000
	Sig. (2-tailed)	,752	1,000	1,000	1,000	1,000		1,000	1,000
	N	22	22	22	22	22	22	22	22
Regression Factor Score for Surrogate Variable @5IBPS6	Pearson Correlation	-,243	,000	,000	,000	,000	,000	1	,000
	Sig. (2-tailed)	,276	1,000	1,000	1,000	1,000	1,000		1,000
	N	22	22	22	22	22	22	22	22
Regression Factor Score for Surrogate Variable @5IBPS7	Pearson Correlation	-,130	,000	,000	,000	,000	,000	,000	1
	Sig. (2-tailed)	,565	1,000	1,000	1,000	1,000	1,000	1,000	
	N	22	22	22	22	22	22	22	22

Table 16.15: Pearson's Correlation Matrix for Best Practices and @DPPS2

According to the Pearson's correlation matrix, the seven surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS2. Hence, the hypothesis *'The Critical Success Best Practices is not influencing the surrogate variable @DPPS2'* is accepted.

16.3.4 <u>Discussion on Hypothesis Test of Best Practices and @DPPS2</u>

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.2*.

The regression model summary shown in *table 16.16* indicates a correlation R = 0.366 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.134 (13.4 %) in the dependent surrogate variable @DPPS2 can be predicted using the seven independent surrogate variables. With seven variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.299) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.147, -0.005, 0.176, 0.017, 0.071, -0.24 and -0.130 for @5IBPS1, @5IBPS2, @5IBPS3, @5IBPS4, @5IBPS5, @5IBPS6 and @5IBPS7 respectively. The seven independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,366*[a]	*,134*	*-,299*	*1,13973655*	*,134*	*,309*	*7*	*14*	*,938*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @5IBPS7, Regression Factor Score for Surrogate Variable @5IBPS6, Regression Factor Score for Surrogate Variable @5IBPS5, Regression Factor Score for Surrogate Variable @5IBPS4, Regression Factor Score for Surrogate Variable @5IBPS3, Regression Factor Score for Surrogate Variable @5IBPS2, Regression Factor Score for Surrogate Variable @5IBPS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*2,814*	*7*	*,402*	*,309*	*,938*[b]
	Residual	*18,186*	*14*	*1,299*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @5IBPS7, Regression Factor Score for Surrogate Variable @5IBPS6, Regression Factor Score for Surrogate Variable @5IBPS5, Regression Factor Score for Surrogate Variable @5IBPS4, Regression Factor Score for Surrogate Variable @5IBPS3, Regression Factor Score for Surrogate Variable @5IBPS2, Regression Factor Score for Surrogate Variable @5IBPS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*1,231E-015*	*,243*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @5IBPS1	*,147*	*,249*	*,147*	*,591*	*,564*

	Regression Factor Score for Surrogate Variable @5IBPS2	-,005	,249	-,005	-,022	,983
	Regression Factor Score for Surrogate Variable @5IBPS3	,176	,249	,176	,709	,490
	Regression Factor Score for Surrogate Variable @5IBPS4	,017	,249	,017	,069	,946
	Regression Factor Score for Surrogate Variable @5IBPS5	,071	,249	,071	,287	,778
	Regression Factor Score for Surrogate Variable @5IBPS6	-,243	,249	-,243	-,977	,345
	Regression Factor Score for Surrogate Variable @5IBPS7	-,130	,249	-,130	-,521	,610
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2						

Table 16.16: Regression Analysis results for Hypothesis 3.2

16.3.5 Hypothesis Test of Best Practices and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of best practices on project performance.

Seven surrogate variables @5IBPS1 (representing @5IBP5, @5IBP12, @5IBP14, @5IBP15, @5IBP16, @5IBP21), @5IBPS2 (representing @5IBP8, @5IBP9, @5IBP10), @5IBPS3 (representing @5IBP4, @5IBP19, @5IBP20), @5IBPS4 (representing @5IBP6, @5IBP7, @5IBP11, @5IBP13), @5IBPS5 (representing @5IBP24, @5IBP25), @5IBPS6 (representing @5IBP23), @5IBPS7 (representing @5IBP17, @5IBP27) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of best practices on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.17*.

Correlations									
		Regression Factor Score for Surrogate Variable @DPPS3	Regression Factor Score for Surrogate Variable @5IBPS1	Regression Factor Score for Surrogate Variable @5IBPS2	Regression Factor Score for Surrogate Variable @5IBPS3	Regression Factor Score for Surrogate Variable @5IBPS4	Regression Factor Score for Surrogate Variable @5IBPS5	Regression Factor Score for Surrogate Variable @5IBPS6	Regression Factor Score for Surrogate Variable @5IBPS7
Regression Factor Score for Surrogate Variable	Pearson Correlation	1	-,403	-,222	-,254	-,090	,065	,355	-,225
	Sig. (2-tailed)		,063	,322	,255	,692	,775	,105	,314

@DPPS3	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS1	Pearson Correlation	*-,403*	*1*	*,000*	*,000*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,063*		*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS2	Pearson Correlation	*-,222*	*,000*	*1*	*,000*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,322*	*1,000*		*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS3	Pearson Correlation	*-,254*	*,000*	*,000*	*1*	*,000*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,255*	*1,000*	*1,000*		*1,000*	*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS4	Pearson Correlation	*-,090*	*,000*	*,000*	*,000*	*1*	*,000*	*,000*	*,000*
	Sig. (2-tailed)	*,692*	*1,000*	*1,000*	*1,000*		*1,000*	*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS5	Pearson Correlation	*,065*	*,000*	*,000*	*,000*	*,000*	*1*	*,000*	*,000*
	Sig. (2-tailed)	*,775*	*1,000*	*1,000*	*1,000*	*1,000*		*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @5IBPS6	Pearson Correlation	*,355*	*,000*	*,000*	*,000*	*,000*	*,000*	*1*	*,000*
	Sig. (2-tailed)	*,105*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*		*1,000*
	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable	Pearson Correlation	*-,225*	*,000*	*,000*	*,000*	*,000*	*,000*	*,000*	*1*
	Sig. (2-tailed)	*,314*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*	

@5IBPS7	N	*22*	*22*	*22*	*22*	*22*	*22*	*22*	*22*

Table 16.17: Pearson's Correlation Matrix for Best Practices and @DPPS3

According to the Pearson's correlation matrix, the seven surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS3. Hence, the hypothesis *'The Critical Success Best Practices is not influencing the surrogate variable @DPPS3'* is accepted.

16.3.6 Discussion on Hypothesis Test of Best Practices and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

The regression model summary shown in *table 16.18* indicates a correlation R = 0.681 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.464 (46.4 %) in the dependent surrogate variable @DPPS3 can be predicted using the seven independent surrogate variables. With seven variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.196) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.403, -0.222, -0.254, -0.090, 0.065, 0.355 and -0.225 for @5IBPS1, @5IBPS2, @5IBPS3, @5IBPS4, @5IBPS5, @5IBPS6 and @5IBPS7 respectively. The seven independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,681[a]*	*,464*	*,196*	*,89646940*	*,464*	*1,733*	*7*	*14*	*,181*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @5IBPS7, Regression Factor Score for Surrogate Variable @5IBPS6, Regression Factor Score for Surrogate Variable @5IBPS5, Regression Factor Score for Surrogate Variable @5IBPS4, Regression Factor Score for Surrogate Variable @5IBPS3, Regression Factor Score for Surrogate Variable @5IBPS2, Regression Factor Score for Surrogate Variable @5IBPS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*9,749*	*7*	*1,393*	*1,733*	*,181[b]*
	Residual	*11,251*	*14*	*,804*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @5IBPS7, Regression Factor Score for Surrogate Variable @5IBPS6, Regression Factor Score for Surrogate Variable @5IBPS5, Regression Factor Score for Surrogate Variable @5IBPS4, Regression Factor Score for Surrogate Variable @5IBPS3, Regression Factor Score for Surrogate Variable @5IBPS2, Regression Factor Score for Surrogate Variable @5IBPS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-3,139E-016*	*,191*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @5IBPS1	*-,403*	*,196*	*-,403*	*-2,058*	*,059*
	Regression Factor Score for Surrogate Variable @5IBPS2	*-,222*	*,196*	*-,222*	*-1,132*	*,277*
	Regression Factor Score for Surrogate Variable @5IBPS3	*-,254*	*,196*	*-,254*	*-1,296*	*,216*
	Regression Factor Score for Surrogate Variable @5IBPS4	*-,090*	*,196*	*-,090*	*-,458*	*,654*
	Regression Factor Score for Surrogate Variable @5IBPS5	*,065*	*,196*	*,065*	*,331*	*,746*
	Regression Factor Score for Surrogate Variable @5IBPS6	*,355*	*,196*	*,355*	*1,813*	*,091*
	Regression Factor Score for Surrogate Variable @5IBPS7	*-,225*	*,196*	*-,225*	*-1,151*	*,269*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3						

Table 16.18: Regression Analysis results for Hypothesis 3.3

16.4 Hypothesis Testing of Information and Communication Technology (ICT)

4. *The Critical Success Factor Information and Communication Technology (ICT) is not influencing the Project performance.*
   4.1. *The Critical Success Factor Information and Communication Technology (ICT) is not influencing the surrogate variable @DPPS1.*
   4.2. *The Critical Success Factor Information and Communication Technology (ICT) is not influencing the surrogate variable @DPPS2.*
   4.3. *The Critical Success Factor Information and Communication Technology (ICT) is not influencing the surrogate variable @DPPS3.*

16.4.1 Hypothesis Test of Information and Communication Technology (ICT) and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in *chapter 15* the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of ICT on project performance.

Two surrogate variables @6IICTS1 (representing @6IICT1, @6IICT2, @6IICT3 and @6IICT4) and @6IICTS2 (representing @6IICT5 and @6IICT6) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of ICT on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.19*.

Correlations				
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @6IICTS1	Regression Factor Score for Surrogate Variable @6IICTS2
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	*1*	*,170*	*,216*
	Sig. (2-tailed)		*,449*	*,334*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @6IICTS1	Pearson Correlation	*,170*	*1*	*,000*
	Sig. (2-tailed)	*,449*		*1,000*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @6IICTS2	Pearson Correlation	*,216*	*,000*	*1*
	Sig. (2-tailed)	*,334*	*1,000*	
	N	*22*	*22*	*22*

Table 16.19: Pearson's Correlation Matrix for ICT and @DPPS1

According to the Pearson's correlation matrix, the two surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS1. Hence, the hypothesis *'The Critical Success Information and Communication Technology (ICT) is not influencing the surrogate variable @DPPS1'* is accepted.

16.4.2 Discussion on Hypothesis Test of ICT and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

The regression model summary shown in *table 16.20* indicates a correlation R = 0.275 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.076 (7.6 %) in the dependent surrogate variable @DPPS1 can be predicted using the two independent surrogate variables. With two variables in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.021) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.170 and 0.216 for @ 6IICTS1 and @ 6IICTS2 respectively. The two independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,275[a]	,076	-,021	1,01069117	,076	,779	2	19	,473

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @6IICTS2, Regression Factor Score for Surrogate Variable @6IICTS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1,592	2	,796	,779	,473[b]
	Residual	19,408	19	1,021		
	Total	21,000	21			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @6IICTS2, Regression Factor Score for Surrogate Variable @6IICTS1

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1,370E-015	,215		,000	1,000
	Regression Factor Score for Surrogate Variable @6IICTS1	,170	,221	,170	,772	,450
	Regression Factor Score for Surrogate Variable @6IICTS2	,216	,221	,216	,981	,339

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

Table 16.20: Regression Analysis results for Hypothesis 4.1

16.4.3 Hypothesis Test of Information and Communication Technology (ICT) and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of ICT on project performance.

Two surrogate variables @6IICTS1 (representing @6IICT1, @6IICT2, @6IICT3 and @6IICT4) and @6IICTS2 (representing @6IICT5 and @6IICT6) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of ICT on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.21*.

Correlations				
		Regression Factor Score for Surrogate Variable @DPPS2	Regression Factor Score for Surrogate Variable @6IICTS1	Regression Factor Score for Surrogate Variable @6IICTS2
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	*1*	*,426**	*,053*
	Sig. (2-tailed)		*,048*	*,814*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @6IICTS1	Pearson Correlation	*,426**	*1*	*,000*
	Sig. (2-tailed)	*,048*		*1,000*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @6IICTS2	Pearson Correlation	*,053*	*,000*	*1*
	Sig. (2-tailed)	*,814*	*1,000*	
	N	*22*	*22*	*22*
*. Correlation is significant at the 0.05 level (2-tailed).				

Table 16.21: Pearson's Correlation Matrix for ICT and @DPPS2

According to the Pearson's correlation matrix, the one of the surrogate independent variables @6IICTS1 showed significant relationship with the dependent surrogate variable @DPPS2 (r = 0.426, Sig.(2-tailed) = 0.048). Hence, the hypothesis *'The Critical Success Information and Communication Technology (ICT) is not influencing the surrogate variable @DPPS2'* is rejected.

16.4.4 Discussion on Hypothesis Test of ICT and @DPPS2

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.2*.

The regression model summary shown in *table 16.22* indicates a correlation R = 0.429 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.184 (18.4 %) in the dependent surrogate variable @DPPS2 can be predicted using the two independent surrogate variables. With two variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.098) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.426 and 0.049 for @ 6IICTS1 and @ 6IICTS2 respectively. One of the two independent surrogate variables is significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of a predictor that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,429[a]*	*,184*	*,098*	*,94971041*	*,184*	*2,141*	*2*	*19*	*,145*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @6IICTS2, Regression Factor Score for Surrogate Variable @6IICTS1						
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2						

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*3,863*	*2*	*1,931*	*2,141*	*,145[b]*
	Residual	*17,137*	*19*	*,902*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @6IICTS2, Regression Factor Score for Surrogate Variable @6IICTS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*1,148E-015*	*,202*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @6IICTS1	*,426*	*,207*	*,426*	*2,054*	*,049*
	Regression Factor Score for Surrogate Variable @6IICTS2	*,053*	*,207*	*,053*	*,256*	*,801*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

Table 16.22: Regression Analysis results for Hypothesis 4.2

16.4.5 Hypothesis Test of Information and Communication Technology (ICT) and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of ICT on project performance.

Two surrogate variables @6IICTS1 (representing @6IICT1, @6IICT2, @6IICT3 and @6IICT4) and @6IICTS2 (representing @6IICT5 and @6IICT6) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of ICT on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.23*.

Correlations				
		Regression Factor Score for Surrogate Variable @DPPS3	Regression Factor Score for Surrogate Variable @6IICTS1	Regression Factor Score for Surrogate Variable @6IICTS2
Regression Factor Score for Surrogate Variable @DPPS3	Pearson Correlation	*1*	*-,192*	*,522*[*]
	Sig. (2-tailed)		*,391*	*,013*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @6IICTS1	Pearson Correlation	*-,192*	*1*	*,000*
	Sig. (2-tailed)	*,391*		*1,000*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @6IICTS2	Pearson Correlation	*,522*[*]	*,000*	*1*
	Sig. (2-tailed)	*,013*	*1,000*	
	N	*22*	*22*	*22*
*. Correlation is significant at the 0.05 level (2-tailed).				

Table 16.23: Pearson's Correlation Matrix for ICT and @DPPS3

According to the Pearson's correlation matrix, the one of the surrogate independent variables @6IICTS2 showed significant relationship with the dependent surrogate variable @DPPS3 (r = 0.522, Sig.(2-tailed) = 0.013). Hence, the hypothesis *'The Critical Success Information and Communication Technology (ICT) is not influencing the surrogate variable @DPPS3'* is rejected.

16.4.6 Discussion on Hypothesis Test of ICT and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

The regression model summary shown in *table 16.24* indicates a correlation R = 0.556 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.309 (30.9 %) in the dependent surrogate variable @DPPS3 can be predicted using the two independent surrogate variables. With two variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.236) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.192 and 0.522 for @ 6IICTS1 and @ 6IICTS2 respectively. One of the two independent surrogate variables is significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of a predictor that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,556*[a]	*,309*	*,236*	*,87386302*	*,309*	*4,250*	*2*	*19*	*,030*
a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @6IICTS2, Regression Factor Score for Surrogate Variable @6IICTS1									

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*6,491*	*2*	*3,245*	*4,250*	*,030*[b]
	Residual	*14,509*	*19*	*,764*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @6IICTS2, Regression Factor Score for Surrogate Variable @6IICTS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-1,985E-016*	*,186*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @6IICTS1	*-,192*	*,191*	*-,192*	*-1,009*	*,326*
	Regression Factor Score for Surrogate Variable @6IICTS2	*,522*	*,191*	*,522*	*2,735*	*,013*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

Table 16.24: Regression Analysis results for Hypothesis 4.3

16.5 Hypothesis Testing of Project Organization

5. *The Critical Success Factor Project Organization is not influencing the Project Performance.*
   - 5.1 *The Critical Success Factor Project Organization is not influencing the surrogate variable @DPPS1.*
   - 5.2 *The Critical Success Factor Project Organization is not influencing the surrogate variable @DPPS2.*
   - 5.3 *The Critical Success Factor Project Organization is not influencing the surrogate variable @DPPS3.*

16.5.1 Hypothesis Test of Project Organization and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in *chapter 15* the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of Project Organization on project performance.

Three surrogate variables @7IPMS1 (representing @7IPM2, @7IPM5, @7IPM7 and @7IPM8), @7IPMS2 (representing @7IPM3 and @7IPM4) and @7IPMS3 (representing @7IPM1 and @7IPM9) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of Project Organization on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.25*.

Correlations					
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @7IPMS1	Regression Factor Score for Surrogate Variable @7IPMS2	Regression Factor Score for Surrogate Variable @7IPMS3
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	*1*	*-,080*	*,053*	*,066*
	Sig. (2-tailed)		*,724*	*,816*	*,769*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @7IPMS1	Pearson Correlation	*-,080*	*1*	*,000*	*,000*
	Sig. (2-tailed)	*,724*		*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @7IPMS2	Pearson Correlation	*,053*	*,000*	*1*	*,000*
	Sig. (2-tailed)	*,816*	*1,000*		*1,000*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @7IPMS3	Pearson Correlation	*,066*	*,000*	*,000*	*1*
	Sig. (2-tailed)	*,769*	*1,000*	*1,000*	
	N	*22*	*22*	*22*	*22*

Table 16.25: Pearson's Correlation Matrix for Project Organization and @DPPS1

According to the Pearson's correlation matrix, the three surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS1. Hence, the hypothesis *'The Critical Success Project Organization is not influencing the surrogate variable @DPPS1'* is accepted.

16.5.2 Discussion on Hypothesis Test of Project Organization and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

The regression model summary shown in *table 16.26* indicates a correlation R = 0.116 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.014 (1.4%) in the dependent surrogate variable @DPPS1 can be predicted using the three independent surrogate variables. With three variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.151) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.08, 0.053 and 0.066 for @7IPMS1, @7IPMS2 and @ 7IPMS3 respectively. The three independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,116*[a]	*,014*	*-,151*	*1,07277067*	*,014*	*,083*	*3*	*18*	*,969*
a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @7IPMS3, Regression Factor Score for Surrogate Variable @7IPMS2, Regression Factor Score for Surrogate Variable @7IPMS1									
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1									

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*,285*	*3*	*,095*	*,083*	*,969*[b]
	Residual	*20,715*	*18*	*1,151*		
	Total	*21,000*	*21*			
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1						
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @7IPMS3, Regression Factor Score for Surrogate Variable @7IPMS2, Regression Factor Score for Surrogate Variable @7IPMS1						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-1,366E-015*	*,229*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @7IPMS1	*-,080*	*,234*	*-,080*	*-,341*	*,737*
	Regression Factor Score for Surrogate Variable @7IPMS2	*,053*	*,234*	*,053*	*,225*	*,824*
	Regression Factor Score for Surrogate Variable @7IPMS3	*,066*	*,234*	*,066*	*,284*	*,780*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1						

Table 16.26: Regression Analysis results for Hypothesis 5.1

16.5.3 Hypothesis Test of Project Organization and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of Project Organization on project performance.

Three surrogate variables @7IPMS1 (representing @7IPM2, @7IPM5, @7IPM7 and @7IPM8), @7IPMS2 (representing @7IPM3 and @7IPM4) and @7IPMS3 (representing @7IPM1 and @7IPM9) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of Project Organization on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.27*.

Correlations					
		Regression Factor Score for Surrogate Variable @DPPS2	Regression Factor Score for Surrogate Variable @7IPMS1	Regression Factor Score for Surrogate Variable @7IPMS2	Regression Factor Score for Surrogate Variable @7IPMS3
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	1	,078	,182	-,045
	Sig. (2-tailed)		,730	,416	,843
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @7IPMS1	Pearson Correlation	,078	1	,000	,000
	Sig. (2-tailed)	,730		1,000	1,000
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @7IPMS2	Pearson Correlation	,182	,000	1	,000
	Sig. (2-tailed)	,416	1,000		1,000
	N	22	22	22	22
Regression Factor Score for Surrogate Variable @7IPMS3	Pearson Correlation	-,045	,000	,000	1
	Sig. (2-tailed)	,843	1,000	1,000	
	N	22	22	22	22

Table 16.27: Pearson's Correlation Matrix for Project Organization and @DPPS2

According to the Pearson's correlation matrix, the three surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS2. Hence, the hypothesis *'The Critical Success Project Organization is not influencing the surrogate variable @DPPS2'* is accepted.

16.5.4 Discussion on Hypothesis Test of Project Organization and @DPPS2

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.2*.

The regression model summary shown in *table 16.28* indicates a correlation R = 0.203 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.041 (4.1 %) in the dependent surrogate variable @DPPS2 can be predicted using the three independent surrogate variables. With three variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.118) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.078, 0.182 and -0.045 for @7IPMS1, @7IPMS2 and @ 7IPMS3 respectively. The three independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]					
Model	R	R Square	Adjusted R	Std. Error of	Change Statistics

			Square	the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	*,203[a]*	*,041*	*-,118*	*1,05754414*	*,041*	*,259*	*3*	*18*	*,854*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @7IPMS3, Regression Factor Score for Surrogate Variable @7IPMS2, Regression Factor Score for Surrogate Variable @7IPMS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*,869*	*3*	*,290*	*,259*	*,854[b]*
	Residual	*20,131*	*18*	*1,118*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @7IPMS3, Regression Factor Score for Surrogate Variable @7IPMS2, Regression Factor Score for Surrogate Variable @7IPMS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*1,189E-015*	*,225*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @7IPMS1	*,078*	*,231*	*,078*	*,338*	*,739*
	Regression Factor Score for Surrogate Variable @7IPMS2	*,182*	*,231*	*,182*	*,791*	*,439*
	Regression Factor Score for Surrogate Variable @7IPMS3	*-,045*	*,231*	*-,045*	*-,194*	*,848*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

Table 16.28: Regression Analysis results for Hypothesis 5.2

16.5.5 Hypothesis Test of Project Organization and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of Project Organization on project performance.

Three surrogate variables @7IPMS1 (representing @7IPM2, @7IPM5, @7IPM7 and @7IPM8), @7IPMS2 (representing @7IPM3 and @7IPM4) and @7IPMS3 (representing @7IPM1 and @7IPM9) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of Project Organization on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.29*.

Correlations					
		Regression Factor Score for Surrogate Variable @DPPS3	Regression Factor Score for Surrogate Variable @7IPMS1	Regression Factor Score for Surrogate Variable @7IPMS2	Regression Factor Score for Surrogate Variable @7IPMS3
Regression Factor Score for Surrogate Variable @DPPS3	Pearson Correlation	*1*	*-,467**	*-,483**	*,262*
	Sig. (2-tailed)		*,028*	*,023*	*,238*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @7IPMS1	Pearson Correlation	*-,467**	*1*	*,000*	*,000*
	Sig. (2-tailed)	*,028*		*1,000*	*1,000*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @7IPMS2	Pearson Correlation	*-,483**	*,000*	*1*	*,000*
	Sig. (2-tailed)	*,023*	*1,000*		*1,000*
	N	*22*	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @7IPMS3	Pearson Correlation	*,262*	*,000*	*,000*	*1*
	Sig. (2-tailed)	*,238*	*1,000*	*1,000*	
	N	*22*	*22*	*22*	*22*
*. Correlation is significant at the 0.05 level (2-tailed).					

Table 16.29: Pearson's Correlation Matrix for Project Organization and @DPPS3

According to the Pearson's correlation matrix, two out of three surrogate independent variables @7IPMS1 and @7IPMS1 showed significant relationship with the dependent surrogate variable @DPPS3 (r = -0.467 and -0.483, Sig.(2-tailed) = 0.028 and 0.023 respectively). Hence, the hypothesis *'The Critical Success Project Organization is not influencing the surrogate variable @DPPS3'* is rejected.

16.5.6 Discussion on Hypothesis Test of Project Organization and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

The regression model summary shown in *table 16.30* indicates a correlation R = 0.721 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.520 (52 %) in the dependent surrogate variable @DPPS3 can be predicted using the three independent surrogate variables. With three variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.440) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.467, -0.483 and 0.262 for @7IPMS1, @7IPMS2 and @ 7IPMS3 respectively. Two of the three independent surrogate variables are significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,721[a]*	*,520*	*,440*	*,74821299*	*,520*	*6,504*	*3*	*18*	*,004*
a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @7IPMS3, Regression Factor Score for Surrogate Variable @7IPMS2, Regression Factor Score for Surrogate Variable @7IPMS1									
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3									

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*10,923*	*3*	*3,641*	*6,504*	*,004[b]*
	Residual	*10,077*	*18*	*,560*		
	Total	*21,000*	*21*			
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3						
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @7IPMS3, Regression Factor Score for Surrogate Variable @7IPMS2, Regression Factor Score for Surrogate Variable @7IPMS1						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-3,408E-016*	*,160*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @7IPMS1	*-,467*	*,163*	*-,467*	*-2,861*	*,010*
	Regression Factor Score for Surrogate Variable @7IPMS2	*-,483*	*,163*	*-,483*	*-2,957*	*,008*
	Regression Factor Score for Surrogate Variable @7IPMS3	*,262*	*,163*	*,262*	*1,608*	*,125*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3						

Table 16.30: Regression Analysis results for Hypothesis 5.3

16.6 Hypothesis Testing of Knowledge Management

6. *The Critical Success Factor Knowledge Management is not influencing the Project Performance.*
   6.1 The Critical Success Factor Knowledge Management is not influencing the surrogate variable @DPPS1.
   6.2 The Critical Success Factor Knowledge Management is not influencing the surrogate variable @DPPS2.
   6.3 The Critical Success Factor Knowledge Management is not influencing the surrogate variable @DPPS3.

16.6.1 Hypothesis Test of Knowledge Management and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in *chapter 15* the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of knowledge management on project performance

Two surrogate variables @8IKMS1 (representing are @8IKM1, @8IKM2, @8IKM3 and @8IKM5) and @8IKMS2 (representing @8IKM4 and @8IKM6) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of knowledge management on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.31*.

Correlations				
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @8IKMS1	Regression Factor Score for Surrogate Variable @8IKMS2
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	*1*	*-,117*	*-,259*
	Sig. (2-tailed)		*,603*	*,245*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @8IKMS1	Pearson Correlation	*-,117*	*1*	*,000*
	Sig. (2-tailed)	*,603*		*1,000*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @8IKMS2	Pearson Correlation	*-,259*	*,000*	*1*
	Sig. (2-tailed)	*,245*	*1,000*	
	N	*22*	*22*	*22*

Table 16.31: Pearson's Correlation Matrix for Knowledge Management and @DPPS1

According to the Pearson's correlation matrix, the two surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS1. Hence, the hypothesis *'The Critical Success Knowledge Management is not influencing the surrogate variable @DPPS1'* is accepted.

16.6.2 Discussion on Hypothesis Test of Knowledge Management and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

The regression model summary shown in *table 16.32* indicates a correlation R = 0.284 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.081 (8.1 %) in the dependent surrogate variable @DPPS1 can be predicted using the two independent surrogate variables. With two variables in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.016) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.117 and -0.259 for @ 8IKMS1 and @ 8IKMS2 respectively. The two independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,284[a]*	*,081*	*-,016*	*1,00796549*	*,081*	*,835*	*2*	*19*	*,449*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @8IKMS2, Regression Factor Score for Surrogate Variable @8IKMS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*1,696*	*2*	*,848*	*,835*	*,449[b]*
	Residual	*19,304*	*19*	*1,016*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @8IKMS2, Regression Factor Score for Surrogate Variable @8IKMS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-1,405E-015*	*,215*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @8IKMS1	*-,117*	*,220*	*-,117*	*-,534*	*,599*
	Regression Factor Score for Surrogate Variable @8IKMS2	*-,259*	*,220*	*-,259*	*-1,176*	*,254*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

Table 16.32: Regression Analysis results for Hypothesis 6.1

16.6.3 Hypothesis Test of Knowledge Management and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of knowledge management on project performance.

Two surrogate variables @8IKMS1 (representing are @8IKM1, @8IKM2, @8IKM3 and @8IKM5) and @8IKMS2 (representing @8IKM4 and @8IKM6) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of knowledge management on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.33*.

Correlations				
		Regression Factor Score for Surrogate Variable @DPPS2	Regression Factor Score for Surrogate Variable @8IKMS1	Regression Factor Score for Surrogate Variable @8IKMS2
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	*1*	*,330*	*-,086*
	Sig. (2-tailed)		*,134*	*,703*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @8IKMS1	Pearson Correlation	*,330*	*1*	*,000*
	Sig. (2-tailed)	*,134*		*1,000*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @8IKMS2	Pearson Correlation	*-,086*	*,000*	*1*
	Sig. (2-tailed)	*,703*	*1,000*	
	N	*22*	*22*	*22*

Table 16.33: Pearson's Correlation Matrix for Knowledge Management and @DPPS2

According to the Pearson's correlation matrix, the two surrogate independent variables showed no significant relationship with the dependent surrogate variable @ DPPS2. Hence, the hypothesis *'The Critical Success Knowledge Management is not influencing the surrogate variable @DPPS2'* is accepted.

16.6.4 Discussion on Hypothesis Test of Knowledge Management and @DPPS2

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.2*.

The regression model summary shown in *table 16.34* indicates a correlation R = 0.341 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.116 (11.6 %) in the dependent surrogate variable @DPPS2 can be predicted using the two independent surrogate variables. With two variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.023) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.330 and -0.086 for @ 8IKMS1 and @ 8IKMS2 respectively. The two independent surrogate variables are not significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of no predictors that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,341[a]	,116	,023	,98836498	,116	1,249	2	19	,309
a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @8IKMS2, Regression Factor Score for Surrogate Variable @8IKMS1									
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2									

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2,440	2	1,220	1,249	,309[b]
	Residual	18,560	19	,977		
	Total	21,000	21			
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2						
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @8IKMS2, Regression Factor Score for Surrogate Variable @8IKMS1						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1,171E-015	,211		,000	1,000
	Regression Factor Score for Surrogate Variable @8IKMS1	,330	,216	,330	1,529	,143
	Regression Factor Score for Surrogate Variable @8IKMS2	-,086	,216	-,086	-,400	,694
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2						

Table 16.34: Regression Analysis results for Hypothesis 6.2

16.6.5 Hypothesis Test of Knowledge Management and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of knowledge management on project performance.

Two surrogate variables @8IKMS1 (representing are @8IKM1, @8IKM2, @8IKM3 and @8IKM5) and @8IKMS2 (representing @8IKM4 and @8IKM6) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of knowledge management on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.35.*

Correlations				
		Regression Factor Score for Surrogate Variable @DPPS3	Regression Factor Score for Surrogate Variable @8IKMS1	Regression Factor Score for Surrogate Variable @8IKMS2
Regression Factor Score for Surrogate Variable @DPPS3	Pearson Correlation	*1*	*-,499[*]*	*-,301*
	Sig. (2-tailed)		*,018*	*,173*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @8IKMS1	Pearson Correlation	*-,499[*]*	*1*	*,000*
	Sig. (2-tailed)	*,018*		*1,000*
	N	*22*	*22*	*22*
Regression Factor Score for Surrogate Variable @8IKMS2	Pearson Correlation	*-,301*	*,000*	*1*
	Sig. (2-tailed)	*,173*	*1,000*	
	N	*22*	*22*	*22*
*. Correlation is significant at the 0.05 level (2-tailed).				

Table 16.35: Pearson's Correlation Matrix for Knowledge Management and @DPPS3

According to the Pearson's correlation matrix, the one of the surrogate independent variables @8IKMS1 showed significant relationship with the dependent surrogate variable @DPPS3 (r = 0.499, Sig.(2-tailed) = 0.018). Hence, the hypothesis *'The Critical Success Knowledge Management is not influencing the surrogate variable @DPPS3'* is rejected.

16.6.6 Discussion on Hypothesis Test of Knowledge Management and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

The regression model summary shown in *table 16.36* indicates a correlation R = 0.583 between the predictors and the predicted values of dependent variables. The variance of the proportion 0.339 (33.9 %) in the dependent surrogate variable @DPPS3 can be predicted using the two independent surrogate variables. With two variables in the analysis, the results showed significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.270) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.499 and -0.301 for @ 8IKMS1 and @ 8IKMS2 respectively. One of the two independent surrogate variables is significantly associated with the dependent surrogate variable at a significance level less than 0.05. In other words, the included set of independent surrogate variables consists of a predictor that can reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,583[a]*	*,339*	*,270*	*,85449582*	*,339*	*4,880*	*2*	*19*	*,019*
a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @8IKMS2, Regression Factor Score for Surrogate Variable @8IKMS1									

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3						
ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*7,127*	*2*	*3,563*	*4,880*	*,019[b]*
	Residual	*13,873*	*19*	*,730*		
	Total	*21,000*	*21*			
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3						
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @8IKMS2, Regression Factor Score for Surrogate Variable @8IKMS1						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-3,040E-016*	*,182*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @8IKMS1	*-,499*	*,186*	*-,499*	*-2,675*	*,015*
	Regression Factor Score for Surrogate Variable @8IKMS2	*-,301*	*,186*	*-,301*	*-1,614*	*,123*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3						

Table 16.36: Regression Analysis results for Hypothesis 6.3

16.7 Hypothesis Testing of Benchmarking

7. The Critical Success Factor Benchmarking is not influencing the Project Performance.

7.1 The Critical Success Factor Benchmarking is not influencing the surrogate variable @DPPS1.

7.2 The Critical Success Factor Benchmarking is not influencing the surrogate variable @DPPS2.

7.3 The Critical Success Factor Benchmarking is not influencing the surrogate variable @DPPS3.

16.7.1 Hypothesis Test of Benchmarking and @DPPS1

The research questionnaire asked the respondents to indicate the Cost/Schedule goals achieved based on policies governing budget/schedule estimates (@3DSP3), Level of customer satisfaction with respect to meeting the quality, schedule and cost goals (@4DPE2), Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job (@4DPE4), Level of Construction performance with respect to productivity, quality adherence and timely completion of the job (@4DPE5), Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality (@5DBP1), Level of Escalation contributed to project cost/schedule due to inferior Construction Quality (@5DBP3). Using the statistical dimension reduction techniques in chapter 15 the six dependent variables have been reduced to a surrogate variable '@DPPS1' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS1 represents the measured effect of benchmarking on project performance.

One surrogate variable @9IBMS1 (representing @9IBM1, @9IBM2 and @9IBM3) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of benchmarking on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.37*.

Correlations			
		Regression Factor Score for Surrogate Variable @DPPS1	Regression Factor Score for Surrogate Variable @9IBMS1
Regression Factor Score for Surrogate Variable @DPPS1	Pearson Correlation	*1*	*-,250*
	Sig. (2-tailed)		*,263*
	N	*22*	*22*
Regression Factor Score for Surrogate Variable @9IBMS1	Pearson Correlation	*-,250*	*1*
	Sig. (2-tailed)	*,263*	
	N	*22*	*22*

Table 16.37: Pearson's Correlation Matrix for Benchmarking and @DPPS1

According to the Pearson's correlation matrix, the surrogate independent variable @9IBMS1 showed no significant relationship with the dependent surrogate variable @ DPPS1. The degree of measure of linear relationship with @ DPPS1 yielded a coefficient of -0.250 (2-tailed) with a p-value greater than 0.05. Based on the analysis, the hypothesis *'The Critical Success Benchmarking is not influencing the surrogate variable @DPPS1'* is accepted.

16.7.2 Discussion on Hypothesis Test of Benchmarking and @DPPS1

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.1*.

The regression model summary shown in *table 16.38* indicates that a proportion of the order 0.062 (6.2 %) variance in the dependent surrogate variable @DPPS1 can be predicted using independent surrogate variable @9IBMS1. With one variable in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.15) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.250 with statistical t-values of -1.152 for @9IBMS1. This means that each unit of @DPPS1 is associated with a score of -0.250 units in @9IBMS1 at a significance level higher than 0.05. This indicates that the independent surrogate variable @9IBMS1 is not statistically and significantly associated with the dependent surrogate variable. In other words, the included independent surrogate variable does not reliably predict the dependent surrogate variable.

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,250[a]*	*,062*	*,015*	*,99228078*	*,062*	*1,328*	*1*	*20*	*,263*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @9IBMS1

b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.

1	Regression	*1,308*	*1*	*1,308*	*1,328*	*,263*[b]
	Residual	*19,692*	*20*	*,985*		
	Total	*21,000*	*21*			
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1						
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @9IBMS1						

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-1,395E-015*	*,212*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @9IBMS1	*-,250*	*,217*	*-,250*	*-1,152*	*,263*
a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS1						

Table 16.38: Regression Analysis results for Hypothesis 7.1

16.7.3 Hypothesis Test of Benchmarking and @DPPS2

The research questionnaire asked the respondents to indicate the Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job (@4DPE3), Amount of Construction rework due to inferior Engineering Quality (@4DPE9), Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality (@5DBP2). Using the statistical dimension reduction techniques in *chapter 15* the three dependent variables have been reduced to a surrogate variable '@DPPS2' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS2 represents the measured effect of benchmarking on project performance.

One surrogate variable @9IBMS1 (representing @9IBM1, @9IBM2 and @9IBM3) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of benchmarking on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.39*.

Correlations

		Regression Factor Score for Surrogate Variable @DPPS2	Regression Factor Score for Surrogate Variable @9IBMS1
Regression Factor Score for Surrogate Variable @DPPS2	Pearson Correlation	*1*	*-,254*
	Sig. (2-tailed)		*,253*
	N	*22*	*22*
Regression Factor Score for Surrogate Variable @9IBMS1	Pearson Correlation	*-,254*	*1*
	Sig. (2-tailed)	*,253*	
	N	*22*	*22*

Table 16.39: Pearson's Correlation Matrix for Benchmarking and @DPPS2

According to the Pearson's correlation matrix, the surrogate independent variable @9IBMS1 showed no significant relationship with the dependent surrogate variable @ DPPS2. The degree of measure of linear relationship with @ DPPS2 yielded a coefficient of -0.254 (2-tailed) with a p-value greater than 0.05.

Based on the analysis, the hypothesis *'The Critical Success Benchmarking is not influencing the surrogate variable @DPPS2'* is accepted.

16.7.4 Discussion on Hypothesis Test of Benchmarking and @DPPS2

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.2*.

The regression model summary shown in *table 16.40* indicates that a proportion of the order 0.065 (6.5 %) variance in the dependent surrogate variable @DPPS2 can be predicted using independent surrogate variable @9IBMS1. With one variable in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = 0.018) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be -0.254 with statistical t-values of -1.177 for @9IBMS1. This means that each unit of @DPPS2 is associated with a score of -0.254 units in @9IBMS1 at a significance level higher than 0.05. This indicates that the independent surrogate variable @9IBMS1 is not statistically and significantly associated with the dependent surrogate variable. In other words, the included independent surrogate variable does not reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	,254[a]	,065	,018	,99097057	,065	1,384	1	20	,253

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @9IBMS1
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1,360	1	1,360	1,384	,253[b]
	Residual	19,640	20	,982		
	Total	21,000	21			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @9IBMS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1,148E-015	,211		,000	1,000
	Regression Factor Score for Surrogate Variable @9IBMS1	-,254	,216	-,254	-1,177	,253

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS2

Table 16.40: Regression Analysis results for Hypothesis 7.2

16.7.5 Hypothesis Test of Benchmarking and @DPPS3

The research questionnaire asked the respondents to indicate the Construction rework due to a team or team member (@5DBP18), Amount of rework as a result of incorrect or inferior quality of information from dependents (@5DBP22). Using the statistical dimension reduction techniques in *chapter 15* the two dependent variables have been reduced to a surrogate variable '@DPPS3' representing the attributes of the aforementioned dependent variables. The surrogate variable @DPPS3 represents the measured effect of benchmarking on project performance.

One surrogate variable @9IBMS1 (representing @9IBM1, @9IBM2 and @9IBM3) deduced from results of the statistical dimension reduction techniques in *chapter 15* shall be used for the hypothesis testing for predicting the effect of benchmarking on project performance.

SPSS v20 has been used by the researcher to calculate the 2-tailed Pearson's correlation coefficient with 20 degrees of freedom and the output is presented using a correlation matrix in *table 16.41*.

Correlations			
		Regression Factor Score for Surrogate Variable @DPPS3	Regression Factor Score for Surrogate Variable @9IBMS1
Regression Factor Score for Surrogate Variable @DPPS3	Pearson Correlation	*1*	*,087*
	Sig. (2-tailed)		*,700*
	N	*22*	*22*
Regression Factor Score for Surrogate Variable @9IBMS1	Pearson Correlation	*,087*	*1*
	Sig. (2-tailed)	*,700*	
	N	*22*	*22*

Table 16.41: Pearson's Correlation Matrix for Benchmarking and @DPPS3

According to the Pearson's correlation matrix, the surrogate independent variable @9IBMS1 showed no significant relationship with the dependent surrogate variable @ DPPS3. The degree of measure of linear relationship with @ DPPS3 yielded a coefficient of -0.087 (2-tailed) with a p-value greater than 0.05. Based on the analysis, the hypothesis *'The Critical Success Benchmarking is not influencing the surrogate variable @DPPS3'* is accepted.

16.7.6 Discussion on Hypothesis Test of Benchmarking and @DPPS3

The researcher used regression analysis to investigate the effect of the independent surrogate variable on the dependent surrogate variables using SPSS v20. The results of the regression analysis confirmed clinging to the normal distribution requirement of the dependent variable as shown in the normal distribution chart and normal P-P plot of regression in *figure 16.3*.

The regression model summary shown in *table 16.42* indicates that a proportion of the order 0.008 (0.8 %) variance in the dependent surrogate variable @DPPS3 can be predicted using independent surrogate variable @9IBMS1. With one variable in the analysis, the results showed no significant difference between the more honest value of coefficient of determination (Adjusted R-square of the research sample population = -0.042) and R-square value. The Unstandardized Coefficient (B), representing the value of the regression equation was found to be 0.087 with statistical t-values of 0.392 for @9IBMS1. This means that each unit of @DPPS3 is associated with a score of 0.087 units in @9IBMS1 at a significance level higher than 0.05. This indicates that the independent surrogate variable @9IBMS1 is not statistically and significantly associated with the dependent surrogate variable. In other words, the included independent surrogate variable does not reliably predict the dependent surrogate variable.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	*,087*[a]	*,008*	*-,042*	*1,02079072*	*,008*	*,153*	*1*	*20*	*,700*

a. Predictors: (Constant), Regression Factor Score for Surrogate Variable @9IBMS1
b. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	*,160*	*1*	*,160*	*,153*	*,700*[b]
	Residual	*20,840*	*20*	*1,042*		
	Total	*21,000*	*21*			

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3
b. Predictors: (Constant), Regression Factor Score for Surrogate Variable @9IBMS1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	*-2,648E-016*	*,218*		*,000*	*1,000*
	Regression Factor Score for Surrogate Variable @9IBMS1	*,087*	*,223*	*,087*	*,392*	*,700*

a. Dependent Variable: Regression Factor Score for Surrogate Variable @DPPS3

Table 16.42: Regression Analysis results for Hypothesis 7.3

17 Relationship Between Variables

17.1 Introduction

Statistical Bivariate analysis results presented will be used by the researcher to infer the possible relationship among the research variables (between dependent variables, between independent variables and between independent and dependent variables) identified and observed. Factor analysis, used as one of the multivariate analysis techniques in this research (results presented in *chapter 15*) will be used to analyze the interdependence among variables and multiple regression analysis along with hypothesis testing (presented in *chapter 16*) will be used to analyze the dependence of one variable can be explained for its effect by other independent variables. This chapter summarizes the relationship between the variables by measuring their strength of relationship. The dimension of strength is presented using Pearson's Correlation Coefficient *'r'* discussed in *chapter 10.* In order to check the statistical significance of the relationship the researcher used a 2-tailed confidence level or significance level of 0.05 and 0.01. The researcher used SPSS v20 to calculate the correlation coefficient.

17.2 Relationship between Independent Variables

This section of the chapter explores the relationship between the independent variables measured for each critical success factor and the independent variables measured for the remaining critical success factors. The hypothesis testing and regression analysis in *chapter 16* intends to discover the possible relationship between dependent and independent variables. To understand the dependencies that are affecting the project performance as one of the research sub-objectives, the researcher examined the independent variables for their strength and direction of linear association. The underlying latent relationship is presented by measuring their strength of association using the Pearson's Correlation Coefficient *'r'* discussed in *chapter 10.*

17.2.1 Front End Planning/Start-Up Plan Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of front end planning/start-up plan and the independent variables observed for the remaining six critical success factors. *Table 17.1* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@3ISP2	Accuracy of policies governing budget/schedule estimates	0,726**	0	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,655**	0,001	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,542**	0,009	@4IPE1	Mobilisation of Start-up resources on time

		0,433*	0,044	@4IPE6	Level of integration between the Project disciplines (E, P and C)
		-0,564**	0,006	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
@3ISP4	Encouragement from Organisation for Start-up Plan formulation	0,462*	0,03	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,509*	0,015	@4IPE7	Level of integration between the engineering disciplines
		-0,475*	0,025	@7IPM1	Level of complexity involved in finding people to gather information
		0,522*	0,013	@7IPM4	Level of relationship/trust on receivers of information
		-0,438*	0,041	@7IPM6	Level of non-productivity due to lack of information from dependents
		0,439*	0,041	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
@3ISP5	Competency of the teams/team members who formulate the start-up plan	0,726**	0	@3ISP2	Accuracy of policies governing budget/schedule estimates
		0,459*	0,032	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,431*	0,045	@4IPE1	Mobilisation of Start-up resources on time
		0,448*	0,037	@5IBP6	Best practices driven to satisfy client requirements
		0,430*	0,046	@5IBP11	Best practices driven by competitors
		0,474*	0,026	@5IBP24	Feedback on the quality of information provided

		-0,450*	0,036	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,423*	0,05	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,542**	0,009	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,541**	0,009	@8IKM6	Efficiency of tools to register and transfer lessons learned into action
@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed	0,655**	0,001	@3ISP2	Accuracy of policies governing budget/schedule estimates
		0,462*	0,03	@3ISP4	Encouragement from Organisation for Start-up Plan formulation
		0,459*	0,032	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,500*	0,018	@4IPE1	Mobilisation of Start-up resources on time
		0,748**	0	@4IPE6	Level of integration between the Project disciplines (E, P and C)
		0,568**	0,006	@4IPE7	Level of integration between the engineering disciplines
		0,431*	0,045	@4IPE13	Timeliness of the dependent disciplines for information
		0,559**	0,007	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,525*	0,012	@5IBP20	Quality of information from dependents
		0,442*	0,04	@7IPM4	Level of relationship/trust on receivers of information

		0,429*	0,046	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,516*	0,014	@8IKM6	Efficiency of tools to register and transfer lessons learned into action
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.1: Relationship Between Independent Variables (Front End Planning/Start-Up Plan)

17.2.2 Project Execution Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of project execution and the independent variables observed for the remaining six critical success factors. *Table 17.2* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@4IPE1	Mobilisation of Start-up resources on time	0,542**	0,009	@3ISP2	Accuracy of policies governing budget/schedule estimates
		0,431*	0,045	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,500*	0,018	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,498*	0,018	@8IKM6	Efficiency of tools to register and transfer lessons learned into action
		0,504*	0,017	@9IBM1	Availability of benchmarking process
		0,426*	0,048	@9IBM2	Frequency of utilisation of benchmarking process
@4IPE6	Level of integration between the Project disciplines (E, P and C)	0,433*	0,044	@3ISP2	Accuracy of policies governing budget/schedule estimates
		0,748**	0	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,703**	0	@4IPE7	Level of integration between the engineering disciplines
		0,451*	0,035	@4IPE13	Timeliness of the dependent disciplines for information
		0,463*	0,03	@5IBP19	Level of on job Quality Control practices/reviews followed on the job

		0,590**	0,004	@5IBP20	Quality of information from dependents
@4IPE7	Level of integration between the engineering disciplines	0,509*	0,015	@3ISP4	Encouragement from Organisation for Start-up Plan formulation
		0,568**	0,006	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,703**	0	@4IPE6	Level of integration between the Project disciplines (E, P and C)
		0,499*	0,018	@5IBP10	Best practices driven by the goal to execute work for the estimated cost and planned schedule
		0,430*	0,046	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,447*	0,037	@6IICT1	Utilisation of communication technology among the disciplines/departments/team members
		0,458*	0,032	@7IPM3	Level of relationship/trust on dependents
		0,658**	0,001	@7IPM4	Level of relationship/trust on receivers of information
		0,451*	0,035	@7IPM5	Level of opportunity/support from the organisation to enhance skills
@4IPE10	Effectiveness of Information Technology applications to monitor progress made during project execution	0,428*	0,047	@5IBP5	Robustness of interdisciplinary best practices
		0,453*	0,034	@5IBP19	Level of on job Quality Control practices/reviews followed on the job
		0,511*	0,015	@5IBP20	Quality of information from dependents
		0,556**	0,007	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		-0,585**	0,004	@9IBM1	Availability of benchmarking process
		-0,652**	0,001	@9IBM2	Frequency of utilisation of benchmarking process
		-0,771**	0	@9IBM3	Quality of benchmarking process

@4IPE13	Timeliness of the dependent disciplines for information	0,431*	0,045	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,451*	0,035	@4IPE6	Level of integration between the Project disciplines (E, P and C)
		0,543**	0,009	@5IBP5	Robustness of interdisciplinary best practices
		0,431*	0,045	@5IBP12	Procedures/work instructions clearly defining the scope of responsibility
		0,443*	0,039	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,445*	0,038	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,854**	0	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution
		0,805**	0	@5IBP21	Timeliness of information from dependents
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.2: Relationship Between Independent Variables (Project Execution)

17.2.3 Best Practices Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of best practices and the independent variables observed for the remaining six critical success factors. *Table 17.3* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@5IBP4	Flexibility of disciplines with respect to adapting the best practices	0,579**	0,005	@5IBP13	Best practices driven by the need to maintain consistency of product/service
		0,438*	0,041	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,592**	0,004	@5IBP20	Quality of information from dependents

		0,568**	0,006	@7IPM4	Level of relationship/trust on receivers of information
@5IBP5	Robustness of interdisciplinary best practices	0,428*	0,047	@4IPE10	Effectiveness of Information Technology applications to monitor progress made during project execution
		0,543**	0,009	@4IPE13	Timeliness of the dependent disciplines for information
		0,446*	0,037	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,488*	0,021	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,605**	0,003	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution
		0,502*	0,017	@5IBP21	Timeliness of information from dependents
		-0,544**	0,009	@7IPM6	Level of non-productivity due to lack of information from dependents
		0,455*	0,033	@8IKM1	Frequency of lessons leaned implementation
		0,595**	0,003	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
@5IBP6	Best practices driven to satisfy client requirements	0,448*	0,037	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,441*	0,04	@5IBP13	Best practices driven by the need to maintain consistency of product/service
		0,483*	0,023	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		-0,489*	0,021	@9IBM2	Frequency of utilisation of benchmarking process
@5IBP7	Best practices driven by Developments in Technology	0,554**	0,007	@5IBP11	Best practices driven by competitors
@5IBP8	Best practices driven by the need to improve engineering quality	0,448*	0,036	@5IBP9	Best practices driven by the need to improve construction quality
		0,796**	0	@5IBP10	Best practices driven by the goal to execute work for the estimated

					cost and planned schedule
		0,568**	0,006	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,548**	0,008	@7IPM4	Level of relationship/trust on receivers of information
		0,598**	0,003	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,449*	0,036	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,519*	0,013	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
@5IBP9	Best practices driven by the need to improve construction quality	0,448*	0,036	@5IBP8	Best practices driven by the need to improve engineering quality
		-0,595**	0,003	@5IBP12	Procedures/work instructions clearly defining the scope of responsibility
		-0,461*	0,031	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,498*	0,018	@5IBP23	Effect of planning on the quality of deliverables
		-0,444*	0,038	@7IPM2	Level of trust on team members
@5IBP10	Best practices driven by the goal to execute work for the estimated cost and planned schedule	0,499*	0,018	@4IPE7	Level of integration between the engineering disciplines
		0,796**	0	@5IBP8	Best practices driven by the need to improve engineering quality
		0,472*	0,026	@7IPM3	Level of relationship/trust on dependents
		0,513*	0,015	@7IPM4	Level of relationship/trust on receivers of information
		0,551**	0,008	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,439*	0,041	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
@5IBP11	Best practices driven by competitors	0,430*	0,046	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,554**	0,007	@5IBP7	Best practices driven by Developments in Technology

		0,462*	0,03	@8IKM1	Frequency of lessons leaned implementation
@5IBP12	Procedures/work instructions clearly defining the scope of responsibility	0,431*	0,045	@4IPE13	Timeliness of the dependent disciplines for information
		-0,595**	0,003	@5IBP9	Best practices driven by the need to improve construction quality
		0,849**	0	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,431*	0,045	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution
		0,510*	0,015	@7IPM2	Level of trust on team members
		-0,498*	0,018	@7IPM6	Level of non-productivity due to lack of information from dependents
		0,470*	0,027	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,494*	0,02	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
@5IBP13	Best practices driven by the need to maintain consistency of product/service	0,579**	0,005	@5IBP4	Flexibility of disciplines with respect to adapting the best practices
		0,441*	0,04	@5IBP6	Best practices driven to satisfy client requirements
		0,428*	0,047	@5IBP20	Quality of information from dependents
		0,477*	0,025	@6IICT3	Efficiency of the tools/applications/process used as common information repository in the project
		0,438*	0,041	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		-0,501*	0,018	@9IBM2	Frequency of utilisation of benchmarking process
@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility	0,443*	0,039	@4IPE13	Timeliness of the dependent disciplines for information
		0,438*	0,041	@5IBP4	Flexibility of disciplines with respect to adapting the best practices
		0,446*	0,037	@5IBP5	Robustness of interdisciplinary best practices

		-0,461*	0,031	@5IBP9	Best practices driven by the need to improve construction quality
		0,849**	0	@5IBP12	Procedures/work instructions clearly defining the scope of responsibility
		0,492*	0,02	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,578**	0,005	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution
		0,526*	0,012	@7IPM2	Level of trust on team members
		0,493*	0,02	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		-0,568**	0,006	@7IPM6	Level of non-productivity due to lack of information from dependents
		0,683**	0	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,514*	0,014	@7IPM8	Competency level of supervisor
		0,484*	0,023	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,555**	0,007	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes	0,559**	0,007	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,430*	0,046	@4IPE7	Level of integration between the engineering disciplines
		0,445*	0,038	@4IPE13	Timeliness of the dependent disciplines for information
		0,488*	0,021	@5IBP5	Robustness of interdisciplinary best practices
		0,568**	0,006	@5IBP8	Best practices driven by the need to improve engineering quality
		0,492*	0,02	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,615**	0,002	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use

					the best practices in project execution
		0,496*	0,019	@6IICT1	Utilisation of communication technology among the disciplines/departments/team members
		0,541**	0,009	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,563**	0,006	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,426*	0,048	@7IPM8	Competency level of supervisor
		0,441*	0,04	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,449*	0,036	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,629**	0,002	@8IKM6	Efficiency of tools to register and transfer lessons learned into action
@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution	0,854**	0	@4IPE13	Timeliness of the dependent disciplines for information
		0,605**	0,003	@5IBP5	Robustness of interdisciplinary best practices
		0,431*	0,045	@5IBP12	Procedures/work instructions clearly defining the scope of responsibility
		0,578**	0,005	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,615**	0,002	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,633**	0,002	@5IBP21	Timeliness of information from dependents
		0,449*	0,036	@8IKM1	Frequency of lessons leaned implementation
		0,426*	0,048	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
@5IBP17	Dedicated team to identify and implement the use best practices in project execution	0,462*	0,03	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,460*	0,031	@8IKM5	Culture of lessons learned process or knowledge management in the

					discipline/project
@5IBP19	Level of on job Quality Control practices/reviews followed on the job	0,463*	0,03	@4IPE6	Level of integration between the Project disciplines (E, P and C)
		0,453*	0,034	@4IPE1 0	Effectiveness of Information Technology applications to monitor progress made during project execution
		0,692**	0	@5IBP2 0	Quality of information from dependents
		-0,699**	0	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,435*	0,043	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,530*	0,011	@7IPM8	Competency level of supervisor
@5IBP20	Quality of information from dependents	0,525*	0,012	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,590**	0,004	@4IPE6	Level of integration between the Project disciplines (E, P and C)
		0,511*	0,015	@4IPE1 0	Effectiveness of Information Technology applications to monitor progress made during project execution
		0,592**	0,004	@5IBP4	Flexibility of disciplines with respect to adapting the best practices
		0,428*	0,047	@5IBP1 3	Best practices driven by the need to maintain consistency of product/service
		0,692**	0	@5IBP1 9	Level of on job Quality Control practices/reviews followed on the job
		-0,452*	0,035	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,481*	0,023	@7IPM4	Level of relationship/trust on receivers of information
		-0,449*	0,036	@9IBM2	Frequency of utilisation of benchmarking process
@5IBP21	Timeliness of information from dependents	0,805**	0	@4IPE1 3	Timeliness of the dependent disciplines for information
		0,502*	0,017	@5IBP5	Robustness of interdisciplinary best practices
		0,633**	0,002	@5IBP1 6	Efficiency of the process/procedure/system used by project/discipline to retain/use

					the best practices in project execution
		0,540**	0,01	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		0,423*	0,05	@7IPM1	Level of complexity involved in finding people to gather information
@5IBP23	Effect of planning on the quality of deliverables	0,498*	0,018	@5IBP9	Best practices driven by the need to improve construction quality
		0,486*	0,022	@7IPM6	Level of non-productivity due to lack of information from dependents
		-0,563**	0,006	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
@5IBP24	Feedback on the quality of information provided	0,474*	0,026	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,464*	0,03	@5IBP25	Feedback on the quality of information received
		-0,429*	0,046	@7IPM1	Level of complexity involved in finding people to gather information
		0,527*	0,012	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,683**	0	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,604**	0,003	@7IPM8	Competency level of supervisor
		0,452*	0,035	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
@5IBP25	Feedback on the quality of information received	0,464*	0,03	@5IBP24	Feedback on the quality of information provided
		0,499*	0,018	@7IPM6	Level of non-productivity due to lack of information from dependents
@5IBP26	Documentation/recording/transferring of the feedback received from dependents into a procedure/best practice	0,490*	0,021	@9IBM1	Availability of benchmarking process
		0,566**	0,006	@9IBM2	Frequency of utilisation of benchmarking process
		0,480*	0,024	@9IBM3	Quality of benchmarking process
@5IBP27	Level of your participation/involve	0,427*	0,048	@7IPM5	Level of opportunity/support from the organisation to enhance

	ment in procedure or work process formulation				skills
		0,424*	0,049	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,489*	0,021	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,642**	0,001	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.3: Relationship Between Independent Variables (Best Practices)

17.2.4 ICT Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of information and communications and the independent variables observed for the remaining six critical success factors. *Table 17.4* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@6IICT1	Utilisation of communication technology among the disciplines/departments/team members	0,447*	0,037	@4IPE7	Level of integration between the engineering disciplines
		0,496*	0,019	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,550**	0,008	@6IICT2	Level of teams adaptability/responsiveness/flexibility to change in ICT
		0,527*	0,012	@6IICT3	Efficiency of the tools/applications/process used as common information repository in the project
		0,535*	0,01	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
@6IICT2	Level of teams adaptability/responsiveness/flexibility to change in ICT	0,550**	0,008	@6IICT1	Utilisation of communication technology among the disciplines/departments/team members
		0,549**	0,008	@6IICT3	Efficiency of the tools/applications/process used as common information repository in

					the project
		0,533*	0,011	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		-0,431*	0,045	@7IPM6	Level of non-productivity due to lack of information from dependents
@6IIC T3	Efficiency of the tools/applications/process used as common information repository in the project	0,477*	0,025	@5IBP13	Best practices driven by the need to maintain consistency of product/service
		0,527*	0,012	@6IICT1	Utilisation of communication technology among the disciplines/departments/team members
		0,549**	0,008	@6IICT2	Level of teams adaptability/responsiveness/flexibility to change in ICT
		0,629**	0,002	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		0,431*	0,045	@8IKM1	Frequency of lessons leaned implementation
@6IIC T4	Level of Information and communication tools/applications alignment with project goals and organisation goals	0,556**	0,007	@4IPE10	Effectiveness of Information Technology applications to monitor progress made during project execution
		0,483*	0,023	@5IBP6	Best practices driven to satisfy client requirements
		0,438*	0,041	@5IBP13	Best practices driven by the need to maintain consistency of product/service
		0,540**	0,01	@5IBP21	Timeliness of information from dependents
		0,535*	0,01	@6IICT1	Utilisation of communication technology among the disciplines/departments/team members
		0,533*	0,011	@6IICT2	Level of teams adaptability/responsiveness/flexibility to change in ICT
		0,629**	0,002	@6IICT3	Efficiency of the tools/applications/process used as common information repository in the project
		-0,438*	0,042	@9IBM2	Frequency of utilisation of benchmarking process

		-0,441*	0,04	@9IBM3	Quality of benchmarking process
@6IICT5	Level of complexity of ICT to receive interdependent information between/across the disciplines	0,623**	0,002	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,472*	0,027	@7IPM1	Level of complexity involved in finding people to gather information
		-0,464*	0,03	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents	-0,564**	0,006	@3ISP2	Accuracy of policies governing budget/schedule estimates
		-0,450*	0,036	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		-0,699**	0	@5IBP19	Level of on job Quality Control practices/reviews followed on the job
		-0,452*	0,035	@5IBP20	Quality of information from dependents
		0,623**	0,002	@6IICT5	Level of complexity of ICT to receive interdependent information between/across the disciplines
		-0,447*	0,037	@7IPM2	Level of trust on team members
		-0,523*	0,013	@7IPM3	Level of relationship/trust on dependents
		-0,447*	0,037	@7IPM7	Flexibility of supervisor to new ideas or processes
		-0,571**	0,006	@7IPM8	Competency level of supervisor
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.4: Relationship Between Independent Variables (ICT)

17.2.5 Project Organization Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of project organization and the independent variables observed for the remaining six critical success factors. *Table 17.5* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@7IPM1	Level of complexity involved in finding people to gather information	-0,475*	0,025	@3ISP4	Encouragement from Organisation for Start-up Plan formulation
		0,423*	0,05	@5IBP21	Timeliness of information from dependents
		-0,429*	0,046	@5IBP24	Feedback on the quality of information provided

		0,472*	0,027	@6IICT5	Level of complexity of ICT to receive interdependent information between/across the disciplines
		-0,460*	0,031	@7IPM7	Flexibility of supervisor to new ideas or processes
@7IPM2	Level of trust on team members	-0,444*	0,038	@5IBP9	Best practices driven by the need to improve construction quality
		0,510*	0,015	@5IBP12	Procedures/work instructions clearly defining the scope of responsibility
		0,526*	0,012	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		-0,447*	0,037	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,556**	0,007	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		-0,468*	0,028	@7IPM6	Level of non-productivity due to lack of information from dependents
		0,502*	0,017	@7IPM7	Flexibility of supervisor to new ideas or processes
@7IPM3	Level of relationship/trust on dependents	0,458*	0,032	@4IPE7	Level of integration between the engineering disciplines
		0,472*	0,026	@5IBP10	Best practices driven by the goal to execute work for the estimated cost and planned schedule
		-0,523*	0,013	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,637**	0,001	@7IPM4	Level of relationship/trust on receivers of information
@7IPM4	Level of relationship/trust on receivers of information	0,522*	0,013	@3ISP4	Encouragement from Organisation for Start-up Plan formulation
		0,442*	0,04	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,658**	0,001	@4IPE7	Level of integration between the engineering disciplines
		0,568**	0,006	@5IBP4	Flexibility of disciplines with respect to adapting the best practices
		0,548**	0,008	@5IBP8	Best practices driven by the need to improve engineering quality
		0,513*	0,015	@5IBP10	Best practices driven by the goal to execute work for the estimated cost and planned schedule

		0,481*	0,023	@5IBP20	Quality of information from dependents
		0,637**	0,001	@7IPM3	Level of relationship/trust on dependents
		0,529*	0,011	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,555**	0,007	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,629**	0,002	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,670**	0,001	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
@7IPM5	Level of opportunity/support from the organisation to enhance skills	0,451*	0,035	@4IPE7	Level of integration between the engineering disciplines
		0,598**	0,003	@5IBP8	Best practices driven by the need to improve engineering quality
		0,551**	0,008	@5IBP10	Best practices driven by the goal to execute work for the estimated cost and planned schedule
		0,493*	0,02	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,541**	0,009	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,527*	0,012	@5IBP24	Feedback on the quality of information provided
		0,427*	0,048	@5IBP27	Level of your participation/involvement in procedure or work process formulation
		0,556**	0,007	@7IPM2	Level of trust on team members
		0,529*	0,011	@7IPM4	Level of relationship/trust on receivers of information
		0,617**	0,002	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,457*	0,033	@7IPM8	Competency level of supervisor
		0,504*	0,017	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,587**	0,004	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures

		0,641**	0,001	@8IKM 5	Culture of lessons learned process or knowledge management in the discipline/project
@7IPM 6	Level of non-productivity due to lack of information from dependents	-0,438*	0,041	@3ISP4	Encouragement from Organisation for Start-up Plan formulation
		-0,544**	0,009	@5IBP5	Robustness of interdisciplinary best practices
		-0,498*	0,018	@5IBP1 2	Procedures/work instructions clearly defining the scope of responsibility
		-0,568**	0,006	@5IBP1 4	Procedures/work instructions clearly defining the expectations of your responsibility
		0,486*	0,022	@5IBP2 3	Effect of planning on the quality of deliverables
		0,499*	0,018	@5IBP2 5	Feedback on the quality of information received
		-0,431*	0,045	@6IICT 2	Level of teams adaptability/responsiveness/flexibility to change in ICT
		-0,468*	0,028	@7IPM2	Level of trust on team members
		-0,656**	0,001	@8IKM 2	Support from organisation to identify, implement and use the lessons learned program
@7IPM 7	Flexibility of supervisor to new ideas or processes	0,423*	0,05	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,449*	0,036	@5IBP8	Best practices driven by the need to improve engineering quality
		0,470*	0,027	@5IBP1 2	Procedures/work instructions clearly defining the scope of responsibility
		0,683**	0	@5IBP1 4	Procedures/work instructions clearly defining the expectations of your responsibility
		0,563**	0,006	@5IBP1 5	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,435*	0,043	@5IBP1 9	Level of on job Quality Control practices/reviews followed on the job
		0,683**	0	@5IBP2 4	Feedback on the quality of information provided
		-0,447*	0,037	@6IICT 6	Level of complexity of the source for retrieving/receiving the information from dependents

		-0,460*	0,031	@7IPM1	Level of complexity involved in finding people to gather information
		0,502*	0,017	@7IPM2	Level of trust on team members
		0,617**	0,002	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,763**	0	@7IPM8	Competency level of supervisor
		0,595**	0,004	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
@7IPM8	Competency level of supervisor	0,514*	0,014	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,426*	0,048	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,530*	0,011	@5IBP19	Level of on job Quality Control practices/reviews followed on the job
		0,604**	0,003	@5IBP24	Feedback on the quality of information provided
		-0,571**	0,006	@6IICT6	Level of complexity of the source for retrieving/receiving the information from dependents
		0,457*	0,033	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,763**	0	@7IPM7	Flexibility of supervisor to new ideas or processes
@7IPM9	Alignment of interest to organisation goal	-0,516*	0,014	@8IKM1	Frequency of lessons leaned implementation
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.5: Relationship Between Independent Variables (Project Organization)

17.2.6 Knowledge Management Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of knowledge management and the independent variables observed for the remaining six critical success factors. *Table 17.6* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@8IKM1	Frequency of lessons leaned	0,455*	0,033	@5IBP5	Robustness of interdisciplinary best practices

	implementation	0,462*	0,03	@5IBP11	Best practices driven by competitors
		0,449*	0,036	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution
		0,431*	0,045	@6IICT3	Efficiency of the tools/applications/process used as common information repository in the project
		-0,516*	0,014	@7IPM9	Alignment of interest to organisation goal
@8IKM2	Support from organisation to identify, implement and use the lessons learned program	0,595**	0,003	@5IBP5	Robustness of interdisciplinary best practices
		0,484*	0,023	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,441*	0,04	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,426*	0,048	@5IBP16	Efficiency of the process/procedure/system used by project/discipline to retain/use the best practices in project execution
		-0,563**	0,006	@5IBP23	Effect of planning on the quality of deliverables
		0,424*	0,049	@5IBP27	Level of your participation/involvement in procedure or work process formulation
		0,555**	0,007	@7IPM4	Level of relationship/trust on receivers of information
		0,504*	0,017	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		-0,656**	0,001	@7IPM6	Level of non-productivity due to lack of information from dependents
		0,770**	0	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,591**	0,004	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project

@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures	0,439*	0,041	@3ISP4	Encouragement from Organisation for Start-up Plan formulation
		0,542**	0,009	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,429*	0,046	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,494*	0,02	@5IBP12	Procedures/work instructions clearly defining the scope of responsibility
		0,555**	0,007	@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility
		0,449*	0,036	@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes
		0,462*	0,03	@5IBP17	Dedicated team to identify and implement the use best practices in project execution
		0,452*	0,035	@5IBP24	Feedback on the quality of information provided
		0,489*	0,021	@5IBP27	Level of your participation/involvement in procedure or work process formulation
		0,629**	0,002	@7IPM4	Level of relationship/trust on receivers of information
		0,587**	0,004	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,595**	0,004	@7IPM7	Flexibility of supervisor to new ideas or processes
		0,770**	0	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,494*	0,019	@8IKM4	Availability of dedicated team to identify and implement the lessons learned in project execution
		0,608**	0,003	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
		0,457*	0,033	@8IKM6	Efficiency of tools to register and transfer lessons learned into

					action
@8IKM4	Availability of dedicated team to identify and implement the lessons learned in project execution	0,494*	0,019	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project	0,519*	0,013	@5IBP8	Best practices driven by the need to improve engineering quality
		0,439*	0,041	@5IBP10	Best practices driven by the goal to execute work for the estimated cost and planned schedule
		0,460*	0,031	@5IBP17	Dedicated team to identify and implement the use best practices in project execution
		0,642**	0,001	@5IBP27	Level of your participation/involvement in procedure or work process formulation
		-0,464*	0,03	@6IICT5	Level of complexity of ICT to receive interdependent information between/across the disciplines
		0,670**	0,001	@7IPM4	Level of relationship/trust on receivers of information
		0,641**	0,001	@7IPM5	Level of opportunity/support from the organisation to enhance skills
		0,591**	0,004	@8IKM2	Support from organisation to identify, implement and use the lessons learned program
		0,608**	0,003	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,460*	0,031	@8IKM6	Efficiency of tools to register and transfer lessons learned into action
@8IKM6	Efficiency of tools to register and transfer lessons learned into action	0,541**	0,009	@3ISP5	Competency of the teams/team members who formulate the start-up plan
		0,516*	0,014	@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed
		0,498*	0,018	@4IPE1	Mobilisation of Start-up resources on time
		0,629**	0,002	@5IBP15	Efficiency of

					tool/system/philosophy to review/analyse/optimise the work processes
		0,457*	0,033	@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures
		0,460*	0,031	@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project
		0,455*	0,033	@9IBM1	Availability of benchmarking process
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.6: Relationship Between Independent Variables (Knowledge Management)

17.2.7 Benchmarking Vs Other Critical Success Factors

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of knowledge management and the independent variables observed for the remaining six critical success factors. *Table 17.7* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@9IBM1	Availability of benchmarking process	0,504*	0,017	@4IPE1	Mobilisation of Start-up resources on time
		-0,585**	0,004	@4IPE10	Effectiveness of Information Technology applications to monitor progress made during project execution
		0,490*	0,021	@5IBP26	Documentation/recording/transferring of the feedback received from dependents into a procedure/best practice
		0,455*	0,033	@8IKM6	Efficiency of tools to register and transfer lessons learned into action
		0,677**	0,001	@9IBM2	Frequency of utilisation of benchmarking process
		0,782**	0	@9IBM3	Quality of benchmarking process
@9IBM2	Frequency of utilisation of benchmarking process	0,426*	0,048	@4IPE1	Mobilisation of Start-up resources on time
		-0,652**	0,001	@4IPE10	Effectiveness of Information Technology applications to monitor progress made during project execution

		-0,489*	0,021	@5IBP6	Best practices driven to satisfy client requirements
		-0,501*	0,018	@5IBP13	Best practices driven by the need to maintain consistency of product/service
		-0,449*	0,036	@5IBP20	Quality of information from dependents
		0,566**	0,006	@5IBP26	Documentation/recording/transferring of the feedback received from dependents into a procedure/best practice
		-0,438*	0,042	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		0,677**	0,001	@9IBM1	Availability of benchmarking process
		0,751**	0	@9IBM3	Quality of benchmarking process
@9IBM3	Quality of benchmarking process	-0,771**	0	@4IPE10	Effectiveness of Information Technology applications to monitor progress made during project execution
		0,480*	0,024	@5IBP26	Documentation/recording/transferring of the feedback received from dependents into a procedure/best practice
		-0,441*	0,04	@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals
		0,782**	0	@9IBM1	Availability of benchmarking process
		0,751**	0	@9IBM2	Frequency of utilisation of benchmarking process
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.7: Relationship Between Independent Variables (Benchmarking)

17.3 Relationship between Independent and Dependent Variables

The section of the chapter explores the relationship between the independent and dependent variables measured for all the critical success factors studied in this research. The hypothesis testing and regression analysis in *chapter 16* discover the possible relationship between dependent and independent variables. However, with the use of dimension reduction technique (factor analysis in *chapter 15*) in this research, the exclusive association between dependent and independent variables missed consideration. In an effort to understand the independent variables that can predict the dependent variables it is necessary that the researcher examines for their strength and direction of linear association. The relationship is examined by measuring their strength of association using the Pearson's Correlation Coefficient *'r'*, discussed in *chapter 10.*

17.3.1 Front End Planning/Start-Up Plan Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of front end planning/start-up plan and the dependent variables. *Table 17.8* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@3ISP4	Encouragement from Organisation for Start-up Plan formulation	-0,477*	0,025	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		-0,487*	0,021	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		-0,459*	0,032	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@3ISP5	Competency of the teams/team members who formulate the start-up plan	-0,595**	0,004	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
@3ISP6	Level of Start-Up Plan alignment for the projects executed or being executed	-0,498*	0,018	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.8: Relationship between Front End Planning/Start-Up Plan and Dependent Variables

17.3.2 Project Execution Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of project execution and the dependent variables. *Table 17.9* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@4IPE1	Mobilisation of Start-up resources on time	-0,527*	0,012	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		-0,568**	0,006	@5DBP2	Level of Escalation contributed to project cost/schedule due to inferior

					Procurement Quality
		-0,476*	0,025	@5DBP18	Construction rework due to a team or team member
@4IPE6	Level of integration between the Project disciplines (E, P and C)	-0,498*	0,018	@4DPE3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job
	Level of integration between the Project disciplines (E, P and C)	0,719**	0	@4DPE9	Amount of Construction rework due to inferior Engineering Quality
	Level of integration between the Project disciplines (E, P and C)	-0,462*	0,03	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@4IPE7	Level of integration between the engineering disciplines	0,625**	0,002	@4DPE9	Amount of Construction rework due to inferior Engineering Quality
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.9: Relationship between Project Execution and Dependent Variables

17.3.3 Best Practices Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of best practices and the dependent variables. *Table 17.10* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@5IBP5	Robustness of interdisciplinary best practices	-0,492*	0,02	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@5IBP9	Best practices driven by the need to improve construction quality	0,426*	0,048	@4DPE3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job
@5IBP13	Best practices driven by the need to maintain consistency of product/service	-0,438*	0,042	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job

@5IBP14	Procedures/work instructions clearly defining the expectations of your responsibility	-0,483*	0,023	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@5IBP15	Efficiency of tool/system/philosophy to review/analyse/optimise the work processes	-0,495*	0,019	@4DPE3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job
		-0,540**	0,01	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@5IBP20	Quality of information from dependents	-0,663**	0,001	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@5IBP24	Feedback on the quality of information provided	-0,499*	0,018	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
@5IBP25	Feedback on the quality of information received	0,537**	0,01	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@5IBP27	Level of your participation/involvement in procedure or work process formulation	-0,539**	0,01	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.10: Relationship between Best Practices and Dependent Variables

17.3.4 ICT Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of information and communications technology and the dependent variables. *Table 17.11* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@6IICT1	Utilisation of communication	-0,487*	0,021	@4DPE3	Level of Engineering performance with

	technology among the disciplines/departments/team members				respect to productivity, quality adherence and timely completion of the job
		0,566**	0,006	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
		0,438*	0,041	@5DBP2	Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality
@6IICT2	Level of teams adaptability/responsiveness/flexibility to change in ICT	0,476*	0,025	@5DBP2	Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality
@6IICT4	Level of Information and communication tools/applications alignment with project goals and organisation goals	0,427*	0,047	@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals
		0,472*	0,027	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
@6IICT5	Level of complexity of ICT to receive interdependent information between/across the disciplines	0,614**	0,002	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		0,555**	0,007	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
		0,423*	0,05	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job
		0,454*	0,034	@5DBP1	Level of Escalation contributed to project cost/schedule due to

					inferior Engineering Quality
		0,481*	0,024	@5DBP18	Construction rework due to a team or team member
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.11: Relationship between ICT and Dependent Variables

17.3.5 Project Organization Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of project organization and the dependent variables. *Table 17.12* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@7IPM2	Level of trust on team members	-0,474*	0,026	@5DBP18	Construction rework due to a team or team member
@7IPM4	Level of relationship/trust on receivers of information	0,458*	0,032	@4DPE9	Amount of Construction rework due to inferior Engineering Quality
		-0,427*	0,047	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@7IPM5	Level of opportunity/support from the organisation to enhance skills	-0,511*	0,015	@5DBP18	Construction rework due to a team or team member
@7IPM6	Level of non-productivity due to lack of information from dependents	0,671**	0,001	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@7IPM7	Flexibility of supervisor to new ideas or processes	-0,452*	0,035	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.12: Relationship between Project Organization and Dependent Variables

17.3.6 Knowledge Management Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of knowledge management and the dependent variables. *Table 17.13* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@8IKM2	Support from organisation to identify, implement and use the lessons learned program	-0,636**	0,001	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@8IKM3	Frequency of Lessons learned getting converted into best practices or procedures	-0,512*	0,015	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@8IKM5	Culture of lessons learned process or knowledge management in the discipline/project	-0,436*	0,043	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@8IKM6	Efficiency of tools to register and transfer lessons learned into action	-0,555**	0,007	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		-0,493*	0,02	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.13: Relationship between Knowledge Management and Dependent Variables

17.3.7 Benchmarking Vs Dependent Variables

The researcher used SPSS v20 to calculate the correlation coefficient *'r'* to explore the relationship between the measured independent variables of benchmarking and the dependent variables. *Table 17.14* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@9IBM1	Availability of benchmarking process	-0,443*	0,039	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job
		-0,524*	0,012	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 17.14: Relationship between Benchmarking and Dependent Variables

17.4 Relationship between Dependent Variables

The hypothesis testing and regression analysis in *chapter 16* discover the possible relationship between dependent and independent variables. However, with the use of dimension reduction technique (factor analysis in *chapter 15*) in this research, the exclusive association between the dependent variables missed consideration. The researcher therefore puts an effort to examine the dependent variables for their strength and direction of linear association. SPSS v20 is used to examine the relationship by measuring their strength of association using the Pearson's Correlation Coefficient *'r'*, discussed in *chapter 10.Table 17.15* presents the association between the variables at a significance level 0.05 and 0.01 (2-tailed).

Variable Code	Variable Description	Correlation Coefficient	Confidence Level (P-Value)	Variable Code	Variable Description
@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates	0,459*	0,032	@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals
		0,637**	0,001	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
		0,756**	0	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job
		0,549**	0,008	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		0,622**	0,002	@5DBP3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality
@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals	0,459*	0,032	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		0,490*	0,021	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
		0,569**	0,006	@4DPE5	Level of Construction performance with respect to

					productivity, quality adherence and timely completion of the job
		0,444*	0,038	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		0,660**	0,001	@5DBP3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality
@4DPE3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job	-0,614**	0,002	@4DPE9	Amount of Construction rework due to inferior Engineering Quality
		-0,635**	0,001	@5DBP2	Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality
@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job	0,637**	0,001	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		0,490*	0,021	@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals
		0,570**	0,006	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job
		0,591**	0,004	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		0,480*	0,024	@5DBP3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality
@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job	0,756**	0	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		0,569**	0,006	@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals
		0,570**	0,006	@4DPE4	Level of Procurement performance with respect to

					productivity, quality adherence and timely completion of the job
		0,559**	0,007	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
		0,593**	0,004	@5DBP3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality
@4DPE9	Amount of Construction rework due to inferior Engineering Quality	-0,614**	0,002	@4DPE3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job
		0,486*	0,022	@5DBP2	Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality
@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality	0,549**	0,008	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		0,444*	0,038	@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals
		0,591**	0,004	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
		0,559**	0,007	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job
		0,619**	0,002	@5DBP3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality
@5DBP2	Level of Escalation contributed to project cost/schedule due to inferior Procurement Quality	-0,635**	0,001	@4DPE3	Level of Engineering performance with respect to productivity, quality adherence and timely completion of the job
		0,486*	0,022	@4DPE9	Amount of Construction rework due to inferior

					Engineering Quality
@5DBP3	Level of Escalation contributed to project cost/schedule due to inferior Construction Quality	0,622**	0,002	@3DSP3	Cost/Schedule goals achieved based on policies governing budget/schedule estimates
		0,660**	0,001	@4DPE2	Level of customer satisfaction with respect to meeting the quality, schedule and cost goals
		0,480*	0,024	@4DPE4	Level of Procurement performance with respect to productivity, quality adherence and timely completion of the job
		0,593**	0,004	@4DPE5	Level of Construction performance with respect to productivity, quality adherence and timely completion of the job
		0,619**	0,002	@5DBP1	Level of Escalation contributed to project cost/schedule due to inferior Engineering Quality
@5DBP18	Construction rework due to a team or team member	0,509*	0,015	@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents
@5DBP22	Amount of rework as a result of incorrect or inferior quality of information from dependents	0,509*	0,015	@5DBP18	Construction rework due to a team or team member
**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).					

Table 17.15: Relationship between Dependent Variables

18 Conclusion

Measuring multidiscipline integration and coordination is a key management control function to gauge the competency of an EPC contractor organization. The projects executed in oil and gas sector involve diverse technical disciplines such as Mechanical, Piping, Electrical, Instrumentation, Structural, Procurement, Construction etc. All the projects executed under an EPC contract have more than one discipline governing its objectives. The requirement is only met when the detailed work break down activities within each technical area are successfully completed. Therefore, coordination between these activities within a discipline along with coordination across the disciplines is essential to execute the project in line with the requirements.

The past few decades has seen EPC contractors trying to find solutions to cope up to the complexities colligated with the significant risks in project execution. Extensive research is done by every contractor with an objective to integrate the schedule and time management functions of an EPC project. Many scholars and researchers developed different methodologies such as utility theory, scheduling milestones, cost milestones, performance index, cost accounting etc. But the focus has primarily been on the construction phase of the project and most often ignores the fact that successful delivery of a project is a synchronous and integrated effort of all the disciplines participating in project execution. The methodologies adapted, do not necessarily provide realistic and practical control functions required to manage the project because of lack of integration and coordination among the project disciplines. An integrated control system is therefore vital to the management as a tool to investigate and gather answers from the project stakeholders. Such a system provides a reflection of the factors that are directly or indirectly impacting the cost, schedule and quality constraints of a project.

Scholars and industry experts believed, concluded and reiterated that a key potential barrier to continuously tackle the competition challenges is the lack of an appropriate measurement system to monitor, check and analyze the effect of improvement actions. The objective of such a tool is to understand the dependencies of the project disciplines and stakeholders that will enable the decision makers to take effect corrective and preventive decision or actions.

The motivation to understand the importance and eventual development of a management control function is more a cultural perspective of an organization. Such a motivation extends beyond the community of researchers whose focus is limited and not within the vantage point. However, in this study, the researcher assumed the role of an interested observer and attempts to capture the commanding perspective view of EPC project execution. With an objective to quantify the efficiency of multidiscipline integration and coordination synonymous to quantifying the effectiveness of the concurrent engineering management system of the research unit, the researcher analyzed four frameworks that can best fit the research unit. With sufficient arguments the researcher deduced and developed a theoretical performance measurement framework based on the characteristics of the organization under study.

Popular literature, exposure to scholarly work and discussions with project stakeholders contributed to defining the critical success factors and the associated terminology. The factors derived henceforth are translated into the required paraphernalia to provide the management with a tool to measure the efficiency of multidiscipline integration and coordination. The identified critical success factors and key influencing factors are a means to identify the deficiencies in the concurrent engineering management system practices at the research unit.

Integration of the critical success factors is important to ensure that the project is carried out as a single unit and meets the stakeholder’s expectations. The process of integration which includes a management plan is the core and most important element governing success of project. An effective management plan is the first and foremost step in executing a project and should always be prepared placed prior to execution of a project.

Project management team and stakeholders should co-ordinate to detail the management plan in order to devise the strategy and detailed functioning of the process as a whole. This plan should be prepared at the start of the project and test parallels using the project's elements and bearing in mind the desired objectives.

The success of a project management methodology and subsequently a project is tied with the process of integrating every process that is part of project execution. Integration has not been identified as important element in previous researches. Lapses or flaws in the integration can result in isolation of a particular process from the other project activities. A well-developed management plan that integrates the functioning of all processes required to execute a project successfully is inevitable. Changes to any aspect of a project management process needs to be reflected in all other project areas.

Measurement of integration and coordination helps to lay down a foundation philosophy in the form of a tool to review the existing improvement status and progress, identify discrepancies, formulate a plan to balance the improvement process and identify the priorities. An environment of optimized integration can be reaped for all the business processes that are critical and which contribute to the production of a tangible or intangible deliverable.

EPC contractor organizations today are forced to adapt to the emerging complexities in project execution and are required to periodically reflect or question their competency and effectiveness. Factors such as increased competition with respect to cost, schedule, quality, safety and technical developments have forced the organizations to question organizational effectiveness and find solutions to remain in the business.

Over the decades EPC organizations have increasingly focused on the formation of teams and work groups to meet the challenges and hence create a competitive edge over its competitors. But time and again it is necessary to explore the use of the techniques for a stronger position in the market. The owners of the oil and gas companies have long back realized the cons of sequential execution of EPC services. The EPC contractor has to realize the need to encourage collective participation and decision making by involving the various specialized groups not at a different time but at times when the need evolves. Most of the organizations do implement some form of principles or practices to achieve project success and organization goals. In addition organization does have the variety of knowledge, ideas and skills to formulate plans that can address the challenges in developing a state-of-art efficient concurrent engineering management system. While some of the principles and techniques have contributed to accomplish the goals initially or partially, there have been setbacks. Hence it makes important for the organizations to lay down a concrete foundation in order to support the necessary improvements.

EPC contractors are frequently faced with a challenge to address the management of diverse interests of the project stakeholders to achieve the project goal. The success of EPC project management depends on the culture and behaviour of the stakeholders who require a common understanding of the factors influencing the project and translate into a business strategy.

The critical success factors and the key influencing factors identified in this research do not necessarily measure the integration and coordination as a whole. Instead of investing too much time and brainstorming efforts to conglomerate all the factors that will provide a basis for the researcher to reach his research objective, only a critical few that could be measured easily and provide sufficient answers are included in this research.

To the management the model is a pilot study tool to explore the inter-dependencies and intra-dependencies of factors that are posing challenges for a successful and efficient execution of a project. The results of this research presented through statistical hypothesis test and relationship among the variables measured, are capable to answer to a large extent at predicting the factors that are impacting the objectives of a project. The research findings are a quick walk through for the management and disciplines into Pandora's Box of issues affecting the success of the organization. The research found a list of causes that are affecting the poor results of a project that can be seen as a step forward to address the efforts to find answers.

Formation of a strategy is not limited to one researcher or an industry expert but is a collaborative and combined effort of organization's collective mind. A collective mind understands as to how the goals and objectives are fragmented throughout the project organization and at the same time how actions can be implemented collectively and consistently.

REFERENCES

Agnitsch, S., Cooke, S. and Solberg, T., 2001. *E.P.C.M. – THE MISUNDERSTOOD CONTRACT* [online]. Available at :< http://www.scribd.com/monikatickoo4412/d/45186108-EPCM-TheMisunderstoodContract> [Accessed 21st January 2012].

Andersen, B. and Pettersen., 1996. *The Benchmarking Handbook: Step-By-Step Instructions*. London: Chapman and Hall.

Brown, M. G., 1999. *Keeping Score: Using the Right Metrics to Drive World-Class Performance*. USA: American Management Association.

Bubshait, A. A., 2003. Incentive/disincentive contracts and its effects on industrial projects. *International Journal of Project Management* [online], 21 (1), pp.63-70. Available at: < http://faculty.kfupm.edu.sa/cem/bushait/research/incentive-disincentive-contracts-its-effects-industria-projects.pdf>[Accessed 24 January 2012].

Camp, R.C., 1989. *Benchmarking: The Search for Industry Best Practices That Lead to Superior Performance*. Wisconsin: ASQC Quality Press

Cannon-Bowers, J. E., Salas, E. and Converse, S., 1993. Shared mental models in expert team decision making. In J. J. Castellan (ed.), *Current issues in individual and group decision making*, pp. 241–246. Lawrence Erlbaum Associates, Hillsdale, NJ.

Carmines, E.G. and Zeller, R.A., 1979. *Reliability and Validity Assessment*, London: Sage Publications.

Chang, R. Y. and DeYoung, P., 1995. *Measuring Organizational Improvement Impact*. Irvine, CA: Richard Chang Associates.

Coakes, S.J. and Steed, L.G., 2007. *SPSS Analysis without Anguish: Version 18.0 For Windows,* Australia: John Wiley and Sons.

Cohen, S. G., and Bailey, D. E., 1997. What makes teams work: Group effectiveness research from the shop floor to the executive suite. *Journal of Management* [online], 23 (3), pp.239-250. Available at: < http://www.stanford.edu/group/wto/cgi-bin/docs/Cohen_Bailey_97.pdf>[Accessed 2 Febraury 2012].

Construction Industry Institute. 1986. *Impact of Various Construction Contract Types and Clauses on Project Performance*. Publication 5-1. Austin, TX: Construction Industry Institute.

Construction Industry Institute. 1986. *Benchmarking Results.* Special Report. Austin, TX: Construction Industry Institute.

Construction Industry Institute .1995. *Pre-project planning hand-book*. Implementation Resource 39(2). Austin, TX: Construction Industry Institute.

Construction Industry Institute .1997. *Alignment during pre-project planning. A Key to Project Success*. Implementation Resource 113-3. Austin, TX: Construction Industry Institute.

Construction Industry Institute. 2006. *Front End Planning Toolkit*. Implementation Resource 213-2. Austin, TX: Construction Industry Institute.

Cooper, D. and Schindler, P., 1998. *Business Research Methods*. 6th ed. Boston: Irwin.

Daniel, D. R., 1961. *Management Information Crisis*. In: *Harvard Business Review, 39(5)*, pp.111-116.
Davis, K., Ledbetter, W.B. and Burati, J.L., 1989. Measuring design and construction quality costs, *Journal of Construction Engineering and Management*, 115(3), pp. 385. Available through: American Society of Civil Engineers Database [Accessed 10 January 2011].

Emory, C.W. and Cooper, D.R., 1991. *Business Research Methods*. 4th ed. Boston: Irwin.

Fergusson, K.J., 1993. *Impact of Integration on Industrial Facility Quality*, Stanford: CIFE.

Fischer, M., 1989. Design Construction Integration Through Constructibility Design Rules for the Preliminary Design of Reinforced Concrete Structures, pp. 333-346. In*: CSCE/CPCA Structural Concrete Conference*, Montreal 20-21 March 1989.

Fischer, M., Betts, M., Hannus, M., Yamazaki, Y. and Laitinen, J., 1993. Goals, dimensions, and approaches for computer integrated construction, pp. 421. In: Mathur, K., Betts, M. and Tham, K.W. (eds.) *Management of informationtechnology for construction*, Singapore: World Scientific Publishing and Global Publications Services

Fox, J., 2008. A Basic Introduction to Missing Data, *740 Sociology.* McMaster University: Unpublished.

Galloway, P., 2009. Design-Build/EPC Contractor's Heightened Risk-Changes in a Changing World. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, [e-journal] 1(1), pp.1-12. Available at: <http://ascelibrary.org/lao/resource/1/jladah/v1/i1/p7_s1?bypassSSO=1 >[Accessed 22 January 2012].

Griffith, A. F. and Gibson, G. E., 2001. Alignment During Preproject Planning. *Journal of Management in Engineering,* 76, Available through: American Society of Civil Engineers Database [Accessed 18 January 2011].

Grunert, K. G. and Ellegaard, C., 1993. The concept of critical success factors: Theory and method. In: Baker, M.J. (Ed.), *Perspectives On Marketing Management*, 3, pp. 245-274. Chichester, UK: John Wiley and Sons.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C., 1998. *Multivariate Data Analysis.* 5th ed., New Jersey: Prentice-Hall.

Handy, C. B., 1981. *Understanding Organizations.* 2nd ed. Harmondsworth: Penguin.

Heppner, P. P., Kivlighan, D. M., Jr., and Wampold, B. E., 1999. *Research design in counselling*, 2nd ed. New York: Brooks/Cole.

Howard, W.E. and Bell, L.C., 1998. *Innovative strategies for contractor compensation*. Research Report 114-11. Austin, TX: Construction Industry Institute.

International programme on the Management of Engineering and Construction (IMEC).1995. *Benchmarking Handbook: Sponsor-contractor relations and innovation in engineering projects*. Montreal: University of Quebec: Unpublished.

Israel, G. D., 1992. *Sampling The Evidence Of Extension Program Impact*. Program Evaluation and Organizational Development, IFAS, University of Florida: PEOD-5.

Kerlinger, F. N., 1986. *Foundations Of Behavioral Research*, 3rd ed . Fort Worth: Holt, Rinehart and Winston, Inc.

Khedro, T., Genesereth, M. R. and Teicholz., 1993. Agent-Based Framework. *International Journal for Engineering* [online], 9 (2), pp.1-3. Available at: <http://dx.doi.org/10.1007/BF01199048>. [Accessed 5th Febraury 2012].
Lawrence, P. and Lorsch, J., 1967. *Organization and Environment*. Boston: Division of Research, Harvard Business School.

Leidecker, J. and Bruno, A., 1984. Identifying and Using Critical Success Factors, *Long Range Planning*, 17(1), pp. 23-32.

Littvay, L., 2009. Questionnaire design considerations with planned missing data. *Review of Psychology* [Online], 16 (2), pp103-113. Available at: < http://mjesec.ffzg.hr/revija.psi/vol%2016%20no%202%202009%20spec%20issue%20psychometrics/revija%204.pdf>[Accessed 25 May 2012].

Liu, H., Han, N. and Han, X. , 2010. *Study on the Optimization of the Bidding Program of the EPC*. [pdf] Available at :< http://www.seiofbluemountain.com/upload/product/201003/2010cygchy03a19.pdf> [Accessed 20 January 2012].

Lunde, H., Sirevaag, A.M. and Tjaland, K., 1995. Cost Effective Strategy for Modification Projects. In: *Offshore Europe*. Aberdeen, United Kingdom 5-8 September 1995. Available through: Onepetro Database [Accessed 28 December 2011].

March, J. G. and Simon, H. A., 1958. *Organizations*. New York: John Wiley and Sons.

McNair, D., Delkousis, J. and Marsh, D., 2004. EPC Contracts - Oil and Gas Sector. *Contracting Practices in Mega Projects*, [e-journal] 22 (4), pp.119-130. Available through: King and Wood Mallesons database [Accessed 21 January 2012].

Memon, A.N., Abro, Q.M. and Mugheri, F., 2011. Quality Management in the Design and Construction Phase:A Case Study. *Mehran University Research Journal of Engineering and Technology* [online], 30 (3), pp511-519. Available at: < http://publications.muet.edu.pk/research_papers/pdf/pdf136.pdf>[Accessed 24 January 2012].

Mintzberg, H., 1983. *Structure in Fives: Designing Effective Organizations*. New Jersey: Prentice-Hall.

Neely, A.D., Adams, C. and Kennerley, M., 2005. *The Performance Prism: The Scorecard for Measuring and Managing Stakeholder Relationships*. Hungarian Edition. London: Prentice Hall.

Pagano, R. R., 2004. *Understanding statistics in the behavioral sciences.*7th ed. Pacific Grove, CA: Brooks Publishing Company.

Performance-Based Management Special Interest Group. (2001). *The Performance-Based Management Handbook*. California: United States Department of Energy (US DOE).

Perrow, C., 1984. *Normal Accidents: Living With High Risk Technologies*. (Revised edition, 1999). Princeton, New Jersey: Princeton University Press.

Pinto, J. and Slevin, D., 1987. Critical Factors in Successful Project Implementation, *IEEE Transactions on Engineering Management*, 34(1), pp. 22-27.

Procurement Executives Association. 2005. *Guide to a Balanced Scorecard: Performance Management Methodology: Moving from Performance Measurement to Performance Management*. USA: Office of Procurement and Assistance Management, US Department of Energy.

Project Management Institute, 1996. *A guide to the project management body of knowledge*. [pdf], Pennsylvania: Project Management Institute. Available at :< http://www.unipi.gr/akad_tmhm/biom_dioik_tech/files/pmbok.pdf> [Accessed 25 January 2012].

Rasmussen, J., 1987. Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinctions in Human Performance Models. In: A. Sage (Eds.), *System Design for Human Interaction* (291-300). New York: IEEE Press.

Rietveld, T. and Van Hout, R., 1993. *Statistical Techniques for the Study of Language and Language Behaviour*. Berlin – New York: Mouton de Gruyter.

Rockart, J. F., 1979. Chief Executives Define Their Own Data Needs. In: *Harvard Business Review*, 57(2), pp. 81-92.

Rubin, D.B., 1976. Inference and Missing Data. *Biometrika*, 63(3), pp 581–592.

Salkind, N.J., 2000. *Exploring Research,* 4th ed. New Jersey: Prentice Hall.

Salvesen, T., 2011. *Contractual Incentives in EPC Contracts*. M.Sc. University of Stavanger.

Schafer , J.L. and Graham, J.W., 2002. Missing data: Our view of the state of the art. *Psychological Methods*, 7, pp147-177.

Sekaran, U., 2003, *Research Methods for Business: A Skill Building Approach*, 4th ed.New York: John Wiley and Sons

Spoonley, P. and Pearson, D.G., 2004. *Tangata Tangata: The Changing Ethnic Contours of New Zealand*. Southbank, Victoria: McPherson.

Teicholz, P. M., and Fischer, M., 1994. A Strategy for Computer Integrated Construction. *Journal of Construction Engineering Management*, 120 (1), p.117. Available through: American Society of Civil Engineers Database [Accessed 3 January 2011].

United States General Accounting Office . 2005. *Performance measurement and evaluations.*Washington D.C: GAO-05-739SP.

Zikmund, W.G., 2000. *Business Research Methods,* 6th ed., Harcourt College Publisher: Fort Worth, Texas.

Appendices

Appendix A: Covering Letter from the Researcher

Pavan Kumar Akella
M.Sc Student
Faculty of Science and Technology
University of Stavanger
Norway

Dear Sir/Madam,

My name is Pavan Kumar Akella and I am currently pursuing my Master's in Offshore Technology with Industrial Asset Management as my specialization at the University of Stavanger. I got an opportunity to do a thesis/dissertation under the supervision of Mr. Nils Erik Olsen and Mr. Eivind Eliassen with the following title.

"At the Crossroads: Multidiscipline Integration and Coordination in an EPC Contract: A Resurgence of Challenges and Strategic Improvement Opportunities"

As part of my dissertation, together with my supervisors, a survey questionnaire has been designed to gather the required information on the organisation's state of the art. I believe your response could provide me with very useful insights and hence am requesting your efforts to kindly answer the enclosed questionnaire.

It will take approximately 30 to 45 minutes to answer the survey questionnaire. It is not necessary to provide any personal details and the information provided by you will strictly be used for research purpose only. The information and the results thereafter will be strictly confidential and will not be disclosed to anybody else or shall not be used for any other purposes.

Please read the following instructions before proceeding to the questionnaire:

- ⇒ Please do not discuss the questions with anybody within or outside the organisation
- ⇒ Please take a print and manually mark it with a pen. No Electronic Copies please.
- ⇒ If a particular question is not relevant to you, then please do not answer it.
- ⇒ Please do not hesitate to contact me for any clarifications
- ⇒ Do not write your names or any other personal information on the questionnaire
- ⇒ Once the questionnaire is completed, please drop it in a box marked 'SURVEY' located behind the reception
- ⇒ Please complete the questionnaire by 15th May 2012

A short background of the dissertation, survey objective and the overall goal is herewith enclosed.

Your response will find great importance and value in successfully achieving my research objective.

Thank you very much for you cooperation and time to participate in this survey.

Best Regards,
Pavan Kumar Akella

Appendix B: Survey Questionnaire

PROJECT MANAGER

Please read the following instructions before proceeding to the questionnaire:

•Please do not discuss the questions with anybody within or outside the organisation
•Please take a print and manually mark it with a pen. No Electronic Copies please.
•If a particular question is not relevant to you, then please do not answer it.
•Please do not hesitate to contact me for any clarifications
•Do not write your names or any other personal information on the questionnaire
•Once the questionnaire is completed, please drop it in a box marked 'SURVEY' located behind the reception

1. RESPONDENT PROFILE

Years of service in the present organisation

- ◯ LESS THAN 1
- ◯ BETWEEN 1 AND 5 YEARS
- ◯ BETWEEN 5 AND 10 YEARS
- ◯ MORE THAN 10 YEARS
- ◯ Other: ______

Number of projects you have been a part of in the present organisation

- ◯ LESS THAN 1
- ◯ BETWEEN 1 AND 5
- ◯ BETWEEN 5 AND 10
- ◯ MORE THAN 10
- ◯ Other: ______

What is Your Present Role in the Project?

______

2. PROJECT SCOPE

Scale the level of project complexity with respect to the competancy of the Organisation for the projects being executed?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the percentage of contracts of type 'Lump Sum' being executed or have been executed by the organisation?

	0	1	2	3	4	5	6	7	8	9	10	
0%	○	○	○	○	○	○	○	○	○	○	○	100%

Scale the percentage of contracts of type 'Unit rate or Unit Price' being executed or have been executed by the organisation?

	0	1	2	3	4	5	6	7	8	9	10	
0%	○	○	○	○	○	○	○	○	○	○	○	100%

Scale the percentage of contracts of type 'Cost Reimbursable Or Cost Plus' being executed or have been executed by the organisation?

	0	1	2	3	4	5	6	7	8	9	10	
0%	○	○	○	○	○	○	○	○	○	○	○	100%

Scale the percentage of contracts of type 'Target Price' being executed or have been executed by the organisation?

	0	1	2	3	4	5	6	7	8	9	10	
0%	○	○	○	○	○	○	○	○	○	○	○	100%

3. PROJECT START-UP PLAN

Startup plan consists of a sequence of activities that begins during requirements definition and extends through initial operations.

Are there any organisation policies/procedures that govern the budget/schedule estimates for the project execution activities?

- YES
- NO
- MAY BE
- DONT KNOW
- Other:

If there are any organisation policies/procedures governing the budget/schedule estimates for the project execution activities, then scale the accuracy of the policies?

	1	2	3	4	5	
NOT ACCURATE						HIGHLY ACCURATE

Based on the current policies/procedures governing the budget/schedule estimates, scale the level of cost/schedule goals achieved for the projects that have been executed or being executed?

	1	2	3	4	5	
NEVER MET GOALS						ALWAYS MET GOALS

Scale the level of encouragement you receive from the organisation for participation in the formulation of a start-up plan?

	1	2	3	4	5	
LOW						HIGH

Scale the competancy of the teams/team members who formulate the start-up plan

	1	2	3	4	5	
LOW						HIGH

Scale the level of Start-Up Plan alignment for the projects executed or being executed

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

4. PROJECT EXECUTION

Are the Start Up resources made available or mobilised at the appropriate time?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ NEVER
- ◯ NOT RELAVANT
- ◯ Other: ________

Scale the level of customer satisfaction with respect to meeting the quality, schedule and cost goals?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of Engineering performance with respect to productivity, quality adherance and timely completion of the job for the projects?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of Procurement performance with respect to productivity, quality adherance and timely completion of the job for the projects?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of Construction performance with respect to productivity, quality adherance and timely completion of the job for the projects?

1 2 3 4 5

LOW ◯ ◯ ◯ ◯ ◯ HIGH

Scale the level of integration between the Project disciplines (E, P and C)?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of integration between the engineering disciplines?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

With the help of existing best practices, scale the benefits realised on project cost, schedule and quality

QUALITY PRACTICES/BEST PRACTICES/PEM/WORK PROCESSES/WORK INSTRUCTIONS/DOCUMENTED GUIDELINES (RULES)

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the amount of construction rework due to inferior Engineering Quality?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the effectiveness of Information Technology applications to monitor progress made during project execution?

Progress monitoring and reporting tools

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

What are types of Incentive Schemes (if any) banked by the Projects that have been executed?

- [ ] Bonus-Penalty Milestones or Incentive-Disincentive
- [ ] Engineering Target Hour’s Incentive
- [ ] Weight Incentive
- [ ] Quality Incentive

- [ ] Project Control Incentive
- [ ] Other: ______

What are types of Incentive Schemes (if any) NOT banked by the Projects that have been executed?

- [ ] Bonus-Penalty Milestones or Incentive-Disincentive
- [ ] Engineering Target Hour's Incentive
- [ ] Weight Incentive
- [ ] Quality Incentive
- [ ] Project Control Incentive
- [ ] Other: ______

In your opinion which of the following 5 most important drivers that require attention to achive project success and organisation goal in your current project?

- [ ] Client Focus
- [ ] Teamwork
- [ ] Communication between Individuals, Teams and Disciplines
- [ ] Collaboration between Individuals, Teams and Disciplines
- [ ] Trust Between Individuals/Teams/Disciplines
- [ ] Available Resouces
- [ ] Leadership Competance
- [ ] Roles and Responsibility Definition
- [ ] Technical Skills
- [ ] Motivation
- [ ] Project management
- [ ] Culture
- [ ] Listening and Feedback
- [ ] Knowledge Management and Transfer
- [ ] Creativity
- [ ] Innovation
- [ ] Shared Values
- [ ] Office Environment
- [ ] Organisation Structure
- [ ] Social Activities
- [ ] Other: ______

5. BEST PRACTICES

QUALITY PRACTICES/BEST PRACTICES/PEM/WORK PROCESSES/WORK INSTRUCTIONS/DOCUMENTED GUIDELINES (RULES)

Scale the level of Escalation contributed to project cost/schedule due to inferior Engineering Quality?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of Escalation contributed to project cost/schedule due to inferior Procurement Quality?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of Escalation contributed to project cost/schedule due to inferior Construction Quality?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the flexibility of disciplines with respect to adapting the best practices

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the robustness of interdisciplinary best practices

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Are the best practices today driven to satisfy client requirements?

○ YES

○ NO

○ MOST OFTEN

- RARELY
- Other:

Are the best practices today driven by Developments in Technology?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to improve engineering quality?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to improve construction quality?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the goal to execute your work for the estimated cost and planned schedule?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by competitors?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to maintain consistency of product/service?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

If there is a tool/system/philosophy in place to review/analyse the work processes, scale the level of its effect in optimizing the work processes?

	1	2	3	4	5	
LOW						HIGH

Scale the efficiency of the process or procedure or a system used by your project/discipline to retain/use the best practices in project execution?

	1	2	3	4	5	
LOW						HIGH

Is there a dedicated team to identify and implement the use best practices in project execution?

- YES
- NO
- DONT KNOW
- MAY BE
- Other:

How often has there been a construction rework because of you or your team?

- YES

- NO
- MOST OFTEN
- RARELY
- Other: ________

Can you specify any unproductive activities that can be eliminated as they are not relevant in the execution of your responsibility?

Do you provide a feedback on the quality of information you receive from whom you depend upon?

- YES
- NO
- MOST OFTEN
- RARELY

Do you document/record/transfer or implement into a procedure/best practice, the feedback you receive from your dependents?

- YES
- NO
- MOST OFTEN
- RARELY

Scale your level of your participation/involvement in procedure or work process formulation

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Can you list any value generating processes that are affecting the project quality, cost and schedule?

Value Generating processes are activities/actions that produce a tangible product(ex: 2D isometric, Line List, PID, Structural drawings etc) or a non-tangible product (ex: Sharing information through meetings and discussion, reporting progress) required for project execution

If best practices are not followed BY YOU OR YOUR TEAM to its requirements, then which of the following best justify as barriers for not using the same in project execution?

- [ ] COMSUMES SIGNIFICANT TIME
- [ ] NO INCENTIVE OR MOTIVATION
- [ ] CULTURAL DIFFERENCES
- [ ] ASSUMPTIVE NATURE
- [ ] HAVE OTHER PRIORITIES
- [ ] NOT ALIGNED TO THE JOB
- [ ] REQUIRES SIGNIFICANT RESOURCES
- [ ] Other:

6. INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Scale the utilisation of communication technology among the disciplines/departments/team members

Examples - Email, Telephone, Common repository Applications , Meetings

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale your team's level of adaptability/responsiveness/flexibility to change in ICT

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the efficiency of the tools/applications/process used as common information repository in the project?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of Information and communication tools/applications alignment with project goals and organisation goals

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the complexity of Information and communication tools/applications to achieve interdependent information or data between/across the disciplines

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

What are the means of communication channels used by your dependents to give a feed back on your quality or timeliness of data?

- [ ] EMAIL
- [ ] PHONE
- [ ] VERBAL
- [ ] WE HAVE A FEEDBACK APPLICATION/PROCEDURE

7. PROJECT ORGANISATION

Scale the level of complexity involved in finding the people from whom you require information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of trust on your team members

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of relationship/trust with people who depend on you for information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of trust/relationship with people whom you depend upon for information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Is the Organisation culture encouraging innovation?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ____________

Which of the following are the potential causes that are affecting your ability to deleiver your responsibilities?

- ☐ My Role and Responsibility Definition
- ☐ Leadership Competance
- ☐ Trust Between Team Members and Supervisors
- ☐ Technical Skills/Competency
- ☐ Too Centralised Project Structure
- ☐ Lot Of Bureaucracy
- ☐ Cultural Differences
- ☐ Too Many Priorities
- ☐ Inefficient/No Work Procedures
- ☐ Complex Work Processes
- ☐ Too Much Focus on Delivery Schedule
- ☐ Communication
- ☐ Insufficient information from whom I Depend Upon
- ☐ Inferior Quality of Information from Whom I Depend Upon

- [ ] Lact Of information about Best Practices
- [ ] Insufficient Training
- [ ] Lack of Orientation towards the Final Delliverable
- [ ] Complex IT Applications
- [ ] Poor IT Application Support
- [ ] Too Much to Deliver
- [ ] Complexity in Gathering Information
- [ ] Other: ____________

Apart from executing your responsibilities during your employment in the organisation, what have you contributed towards project success and organisation goal?

8. KNOWLEDGE MANAGEMENT (LESSONS LEARNED)

Knowledge management is a process of capturing, recording, transfering and implementing the solutions that evolve as a result of high level of reasoning and problem solving.

How frequently do you think the projects executed or being executed are identifying, implementing and using the lessons learned in project execution?

- ( ) Continuously
- ( ) Occasionally
- ( ) Only When there is a need
- ( ) Rarely
- ( ) Never
- ( ) Other: ____________

Do you receive adequate support from the organisation to identify, implement and use the lessons learned program?

- ◯ YES
- ◯ NO
- ◯ SOMETIMES YES; SOMETIMES NO
- ◯ Other: ______

According to you are the lessons learned getting converted into best practices or procedures?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ______

Is there a dedicated team to identify and implement the lessons learned in project execution?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ______

Grade the culture of lessons learned process or knowledge management in your discipline/project?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

If there are any tools available to register and transfer lessons learned into action, then Scale the efficiency of the tools?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

According to you, what are the potential challenges faced in implementing lessons learned process to the project and organisation ?

- ☐ Resource Constraints

- [ ] Consumes Time
- [ ] Not a Priority
- [ ] Dont see Significant Value in Lessons Learned
- [ ] No data is Available to register Lessons Learned
- [ ] Employee Motivation
- [ ] No Incentive
- [ ] Other: ______

9. BENCH MARKING (BETWEEN PROJECTS)

The organisation's activity of comparing context, processes, strategies and outputs across firms and within concurrent internal projects/disciplines in order to evaluate one's position with respect to other firms/projects/disciplines to identify, adapt, and implement the best practices

If there a benchmarking process for your project/discipline?

- ( ) YES
- ( ) NO
- ( ) Other: ______

If there is a benchmarking process for your project/discipline, how frequently it is used?

- ( ) CONTINUOUSLY
- ( ) OCCASIONALLY
- ( ) NEVER
- ( ) Other: ______

If there is a benchmarking process for your project/discipline, scale the Quality of Benchmarking?

	1	2	3	4	5	
LOW	( )	( )	( )	( )	( )	HIGH

If there is no benchmarking process of the project in the Organisation, How do you measure your projects/disciplines performance with respect to other projects?

Submit

DISCIPLINE/TEAM LEAD

Please read the following instructions before proceeding to the questionnaire:

•Please do not discuss the questions with anybody within or outside the organisation
•Please take a print and manually mark it with a pen. No Electronic Copies please.
•If a particular question is not relevant to you, then please do not answer it.
•Please do not hesitate to contact me for any clarifications
•Do not write your names or any other personal information on the questionnaire
•Once the questionnaire is completed, please drop it in a box marked 'SURVEY' located behind the reception

1. RESPONDENT PROFILE

DISCIPLINE

[ ]

Years of service in the present organisation

- ○ LESS THAN 1
- ○ BETWEEN 1 AND 5 YEARS
- ○ BETWEEN 5 AND 10 YEARS
- ○ MORE THAN 10 YEARS
- ○ Other: [ ]

Number of projects you have been a part of in the present organisation

- ○ LESS THAN 1
- ○ BETWEEN 1 AND 5
- ○ BETWEEN 5 AND 10
- ○ MORE THAN 10
- ○ Other: [ ]

What is Your Present Role in the Project?

2. PROJECT SCOPE

Scale the level of project complexity with respect to the competancy of the Organisation for the projects being executed?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

3. PROJECT START-UP PLAN

Startup plan consists of a sequence of activities that begins during requirements definition and extends through initial operations.

Are there any organisation policies/procedures that govern the budget/schedule estimates for the project execution activities?

- ◯ YES
- ◯ NO
- ◯ MAY BE
- ◯ DONT KNOW
- ◯ Other:

If there are any organisation policies/procedures governing the budget/schedule estimates for the project execution activities, then scale the accuracy of the policies?

	1	2	3	4	5	
NOT ACCURATE	◯	◯	◯	◯	◯	HIGHLY ACCURATE

Scale the level of encouragement you receive from the organisation for participation in the formulation of a start-up plan?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the competancy of the teams/team members who formulate the start-up plan

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of Start-Up Plan alignment for the projects executed or being executed

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

4. PROJECT EXECUTION

Are the Start Up resources made available or mobilised at the appropriate time?

- ○ YES
- ○ NO
- ○ MOST OFTEN
- ○ NEVER
- ○ NOT RELAVANT
- ○ Other: ____________

Scale the level of integration between the Project disciplines (E, P and C)?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of integration between the engineering disciplines?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the timeliness of the disciplines you depend upon for the information you need?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the amount of construction rework due to inferior Engineering Quality?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the effectiveness of Information Technology applications to monitor progress made during project execution?

Progress monitoring and reporting tools

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

In your opinion which of the following 5 most important drivers that require attention to achive project success and organisation goal in your current project?

- ☐ Client Focus
- ☐ Teamwork
- ☐ Communication between Individuals, Teams and Disciplines
- ☐ Collaboration between Individuals, Teams and Disciplines
- ☐ Trust Between Individuals/Teams/Disciplines
- ☐ Available Resouces
- ☐ Leadership Competance
- ☐ Roles and Responsibility Definition
- ☐ Technical Skills
- ☐ Motivation
- ☐ Project management
- ☐ Culture
- ☐ Listening and Feedback
- ☐ Knowledge Management and Transfer
- ☐ Creativity
- ☐ Innovation
- ☐ Shared Values
- ☐ Office Environment

☐ Organisation Structure

☐ Social Activities

☐ Other: ____________

5. BEST PRACTICES

QUALITY PRACTICES/BEST PRACTICES/PEM/WORK PROCESSES/WORK INSTRUCTIONS/DOCUMENTED GUIDELINES (RULES)

Scale the flexibility of disciplines with respect to adapting the best practices

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the robustness of interdisciplinary best practices

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Are the best practices today driven to satisfy client requirements?

○ YES

○ NO

○ MOST OFTEN

○ RARELY

○ Other: ____________

Are the best practices today driven by Developments in Technology?

○ YES

○ NO

○ MOST OFTEN

○ RARELY

○ Other: ____________

Are the best practices today driven by the need to improve engineering quality?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to improve construction quality?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the goal to execute your work for the estimated cost and planned schedule?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by competitors?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the present procedures/work instructions clearly defining the scope of your responsibility?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to maintain consistency of product/service?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the present procedures/work instructions clearly defining the expectations of your responsibility?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

If there is a tool/system/philosophy in place to review/analyse the work processes, scale the level of its effect in optimizing the work processes?

	1	2	3	4	5	
LOW						HIGH

Scale the efficiency of the process or procedure or a system used by your project/discipline to retain/use the best practices in project execution?

	1	2	3	4	5	
LOW						HIGH

Is there a dedicated team to identify and implement the use best practices in project execution?

- YES
- NO
- DONT KNOW
- MAY BE
- Other:

How often has there been a construction rework because of you or your team?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ______

Scale the level of Quality Control practices/reviews followed on your Job

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the Quality of information you receive from whom you depend upon

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the timeliness of the disciplines you depend upon for the information you need?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the amount of rework you have to do as a result of the quality of information you receive from whom you depend upon?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the affect of planning or stringent delievery times on the quality of your deliverable

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Can you specify any unproductive activities that can be eliminated as they are not relevant in the execution of your responsibility?

Do you get a feedback on the quality of information you provide?

- YES
- NO
- MOST OFTEN
- RARELY

Do you provide a feedback on the quality of information you receive from whom you depend upon?

- YES
- NO
- MOST OFTEN
- RARELY

Do you document/record/transfer or implement into a procedure/best practice, the feedback you receive from your dependents?

- YES
- NO
- MOST OFTEN
- RARELY

Scale your level of your participation/involvement in procedure or work process formulation

	1	2	3	4	5	
LOW						HIGH

Can you list any value generating processes that are affecting the project quality, cost and schedule?

Value Generating processes are activities/actions that produce a tangible product(ex: 2D isometric, Line List, PID, Structural drawings etc) or a non-tangible product (ex: Sharing information through meetings and discussion, reporting progress) required for project execution

If best practices are not followed BY YOU OR YOUR TEAM to its requirements, then which of the following best justify as barriers for not using the same in project execution?

- [ ] COMSUMES SIGNIFICANT TIME
- [ ] NO INCENTIVE OR MOTIVATION
- [ ] CULTURAL DIFFERENCES
- [ ] ASSUMPTIVE NATURE
- [ ] HAVE OTHER PRIORITIES
- [ ] NOT ALIGNED TO THE JOB
- [ ] REQUIRES SIGNIFICANT RESOURCES
- [ ] Other:

6. INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Scale the utilisation of communication technology among the disciplines/departments/team members

Examples - Email, Telephone, Common repository Applications, Meetings

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale your team's level of adaptability/responsiveness/flexibility to change in ICT

	1	2	3	4	5

LOW ○ ○ ○ ○ ○ HIGH

Scale the efficiency of the tools/applications/process used as common information repository in the project?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of Information and communication tools/applications alignment with project goals and organisation goals

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the complexity of Information and communication tools/applications to achieve interdependent information or data between/across the disciplines

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of complexity of the source used for retrieving/receiving the information from whom you depend upon?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

What are the means of communication channels used by your dependents to give a feed back on your quality or timeliness of data?

- [ ] EMAIL
- [ ] PHONE
- [ ] VERBAL
- [ ] WE HAVE A FEEDBACK APPLICATION/PROCEDURE

7.PROJECT ORGANISATION

Scale the level of complexity involved in finding the people from whom you require information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of trust on your team members

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of relationship/trust with people who depend on you for information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of trust/relationship with people whom you depend upon for information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of opportunity/support you receive from the organisation to enhance your skills

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of non-productivity as a result of lack of information from whom you depend upon?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the flexibility of your supervisor to new ideas or processes

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the competency level of your supervisor

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Is you interest aligned to the organisation goal?

- ○ YES
- ○ NO
- ○ Other: ____

Is the Organisation culture encouraging innovation?

- ○ YES
- ○ NO
- ○ MOST OFTEN
- ○ RARELY
- ○ Other: ____

Which of the following are the potential causes that are affecting your ability to deleiver your responsibilities?

- ☐ My Role and Responsibility Definition
- ☐ Leadership Competance
- ☐ Trust Between Team Members and Supervisors
- ☐ Technical Skills/Competency
- ☐ Too Centralised Project Structure
- ☐ Lot Of Bureaucracy
- ☐ Cultural Differences
- ☐ Too Many Priorities
- ☐ Inefficient/No Work Procedures
- ☐ Complex Work Processes
- ☐ Too Much Focus on Delivery Schedule
- ☐ Communication
- ☐ Insufficient information from whom I Depend Upon
- ☐ Inferior Quality of Information from Whom I Depend Upon
- ☐ Lact Of information about Best Practices
- ☐ Insufficient Training
- ☐ Lack of Orientation towards the Final Delliverable
- ☐ Complex IT Applications
- ☐ Poor IT Application Support

- [ ] Too Much to Deliver
- [ ] Complexity in Gathering Information
- [ ] Other: ________

Apart from executing your responsibilities during your employment in the organisation, what have you contributed towards project success and organisation goal?

8. KNOWLEDGE MANAGEMENT (LESSONS LEARNED)

Knowledge management is a process of capturing, recording, transfering and implementing the solutions that evolve as a result of high level of reasoning and problem solving.

How frequently do you think the projects executed or being executed are identifying, implementing and using the lessons learned in project execution?

- ○ Continuously
- ○ Occasionally
- ○ Only When there is a need
- ○ Rarely
- ○ Never
- ○ Other: ________

Do you receive adequate support from the organisation to identify, implement and use the lessons learned program?

- ○ YES
- ○ NO
- ○ SOMETIMES YES; SOMETIMES NO
- ○ Other: ________

According to you are the lessons learned getting converted into best practices or procedures?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Is there a dedicated team to identify and implement the lessons learned in project execution?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Grade the culture of lessons learned process or knowledge management in your discipline/project?

	1	2	3	4	5	
LOW						HIGH

If there are any tools available to register and transfer lessons learned into action, then Scale the efficiency of the tools?

	1	2	3	4	5	
LOW						HIGH

According to you, what are the potential challenges faced in implementing lessons learned process to the project and organisation ?

- Resource Constraints
- Consumes Time
- Not a Priority
- Dont see Significant Value in Lessons Learned
- No data is Available to register Lessons Learned
- Employee Motivation

- [ ] No Incentive
- [ ] Other: ____

9. BENCH MARKING (BETWEEN PROJECTS)

The organisation's activity of comparing context, processes, strategies and outputs across firms and within concurrent internal projects/disciplines in order to evaluate one's position with respect to other firms/projects/disciplines to identify, adapt, and implement the best practices

If there a benchmarking process for your project/discipline?

- ( ) YES
- ( ) NO
- ( ) Other: ____

If there is a benchmarking process for your project/discipline, how frequently it is used?

- ( ) CONTINUOUSLY
- ( ) OCCASIONALLY
- ( ) NEVER
- ( ) Other: ____

If there is a benchmarking process for your project/discipline, scale the Quality of Benchmarking?

	1	2	3	4	5	
LOW	( )	( )	( )	( )	( )	HIGH

If there is no benchmarking process of the project in the Organisation, How do you measure your projects/disciplines performance with respect to other projects?

Submit

TEAM MEMBER

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- •Please do not discuss the questions with anybody within or outside the organisation
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- •Please do not hesitate to contact me for any clarifications
- •Do not write your names or any other personal information on the questionnaire
- •Once the questionnaire is completed, please drop it in a box marked 'SURVEY' located behind the reception

1. RESPONDENT PROFILE

DISCIPLINE

[ ]

Years of service in the present organisation

- ( ) LESS THAN 1
- ( ) BETWEEN 1 AND 5 YEARS
- ( ) BETWEEN 5 AND 10 YEARS
- ( ) MORE THAN 10 YEARS
- ( ) Other: [ ]

Number of projects you have been a part of in the present organisation

- ( ) LESS THAN 1
- ( ) BETWEEN 1 AND 5
- ( ) BETWEEN 5 AND 10
- ( ) MORE THAN 10
- ( ) Other: [ ]

What is Your Present Role in the Project?

4.PROJECT EXECUTION

Scale the timeliness of the disciplines you depend upon for the information you need?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the amount of construction rework due to inferior Engineering Quality?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

In your opinion which of the following 5 most important drivers that require attention to achive project success and organisation goal in your current project?

- ☐ Client Focus
- ☐ Teamwork
- ☐ Communication between Individuals, Teams and Disciplines
- ☐ Collaboration between Individuals, Teams and Disciplines
- ☐ Trust Between Individuals/Teams/Disciplines
- ☐ Available Resouces
- ☐ Leadership Competance
- ☐ Roles and Responsibility Definition
- ☐ Technical Skills
- ☐ Motivation
- ☐ Project management
- ☐ Culture
- ☐ Listening and Feedback
- ☐ Knowledge Management and Transfer
- ☐ Creativity
- ☐ Innovation
- ☐ Shared Values
- ☐ Office Environment
- ☐ Organisation Structure

- [ ] Social Activities
- [ ] Other: ____________

5.BEST PRACTICES

QUALITY PRACTICES/BEST PRACTICES/PEM/WORK PROCESSES/WORK INSTRUCTIONS/DOCUMENTED GUIDELINES (RULES)

Scale the flexibility of disciplines with respect to adapting the best practices

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the robustness of interdisciplinary best practices

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Are the best practices today driven to satisfy client requirements?

- ○ YES
- ○ NO
- ○ MOST OFTEN
- ○ RARELY
- ○ Other: ____________

Are the best practices today driven by Developments in Technology?

- ○ YES
- ○ NO
- ○ MOST OFTEN
- ○ RARELY
- ○ Other: ____________

Are the best practices today driven by the need to improve engineering quality?

- ○ YES

- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to improve construction quality?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the goal to execute your work for the estimated cost and planned schedule?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by competitors?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the present procedures/work instructions clearly defining the scope of your responsibility?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Are the best practices today driven by the need to maintain consistency of product/service?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ________

Are the present procedures/work instructions clearly defining the expectations of your responsibility?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ________

If there is a tool/system/philosophy in place to review/analyse the work processes, scale the level of its effect in optimizing the work processes?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the efficiency of the process or procedure or a system used by your project/discipline to retain/use the best practices in project execution?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Is there a dedicated team to identify and implement the use best practices in project execution?

- ◯ YES
- ◯ NO
- ◯ DONT KNOW
- ◯ MAY BE
- ◯ Other: ________

How often has there been a construction rework because of you or your team?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ______

Scale the level of Quality Control practices/reviews followed on your Job

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the Quality of information you receive from whom you depend upon

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the timeliness of the disciplines you depend upon for the information you need?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the amount of rework you have to do as a result of the quality of information you receive from whom you depend upon?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the affect of planning or stringent delievery times on the quality of your deliverable

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Can you specify any unproductive activities that can be eliminated as they are not relevant in the execution of your responsibility?

Do you get a feedback on the quality of information you provide?

- YES
- NO
- MOST OFTEN
- RARELY

Do you provide a feedback on the quality of information you receive from whom you depend upon?

- YES
- NO
- MOST OFTEN
- RARELY

Do you document/record/transfer or implement into a procedure/best practice, the feedback you receive from your dependents?

- YES
- NO
- MOST OFTEN
- RARELY

Scale your level of your participation/involvement in procedure or work process formulation

	1	2	3	4	5	
LOW						HIGH

Can you list any value generating processes that are affecting the project quality, cost and schedule?

Value Generating processes are activities/actions that produce a tangible product(ex: 2D isometric, Line List, PID, Structural drawings etc) or a non-tangible product (ex: Sharing information through meetings and discussion, reporting progress) required for project execution

If best practices are not followed BY YOU OR YOUR TEAM to its requirements, then which of the following best justify as barriers for not using the same in project execution?

- [ ] COMSUMES SIGNIFICANT TIME
- [ ] NO INCENTIVE OR MOTIVATION
- [ ] CULTURAL DIFFERENCES
- [ ] ASSUMPTIVE NATURE
- [ ] HAVE OTHER PRIORITIES
- [ ] NOT ALIGNED TO THE JOB
- [ ] REQUIRES SIGNIFICANT RESOURCES
- [ ] Other:

6.INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Scale the utilisation of communication technology among the disciplines/departments/team members

Examples - Email, Telephone, Common repository Applications, Meetings

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale your team's level of adaptability/responsiveness/flexibility to change in ICT

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the efficiency of the tools/applications/process used as common information repository in the project?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of Information and communication tools/applications alignment with project goals and organisation goals

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the complexity of Information and communication tools/applications to achieve interdependent information or data between/across the disciplines

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

Scale the level of complexity of the source used for retrieving/receiving the information from whom you depend upon?

	1	2	3	4	5	
LOW	○	○	○	○	○	HIGH

What are the means of communication channels used by your dependents to give a feed back on your quality or timeliness of data?

- ☐ EMAIL
- ☐ PHONE
- ☐ VERBAL
- ☐ WE HAVE A FEEDBACK APPLICATION/PROCEDURE

7. PROJECT ORGANISATION

Scale the level of complexity involved in finding the people from whom you require information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of trust on your team members

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of relationship/trust with people who depend on you for information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale your level of trust/relationship with people whom you depend upon for information

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of opportunity/support you receive from the organisation to enhance your skills

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the level of non-productivity as a result of lack of information from whom you depend upon?

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Scale the flexibility of your supervisor to new ideas or processes

1 2 3 4 5

LOW ◯ ◯ ◯ ◯ ◯ HIGH

Scale the competency level of your supervisor

	1	2	3	4	5	
LOW	◯	◯	◯	◯	◯	HIGH

Is you interest aligned to the organisation goal?

- ◯ YES
- ◯ NO
- ◯ Other: ______

Is the Organisation culture encouraging innovation?

- ◯ YES
- ◯ NO
- ◯ MOST OFTEN
- ◯ RARELY
- ◯ Other: ______

Which of the following are the potential causes that are affecting your ability to deleiver your responsibilities?

- ☐ My Role and Responsibility Definition
- ☐ Leadership Competance
- ☐ Trust Between Team Members and Supervisors
- ☐ Technical Skills/Competency
- ☐ Too Centralised Project Structure
- ☐ Lot Of Bureaucracy
- ☐ Cultural Differences
- ☐ Too Many Priorities
- ☐ Inefficient/No Work Procedures
- ☐ Complex Work Processes
- ☐ Too Much Focus on Delivery Schedule
- ☐ Communication
- ☐ Insufficient information from whom I Depend Upon
- ☐ Inferior Quality of Information from Whom I Depend Upon
- ☐ Lact Of information about Best Practices
- ☐ Insufficient Training

- [ ] Lack of Orientation towards the Final Delliverable
- [ ] Complex IT Applications
- [ ] Poor IT Application Support
- [ ] Too Much to Deliver
- [ ] Complexity in Gathering Information
- [ ] Other:

Apart from executing your responsibilities during your employment in the organisation, what have you contributed towards project success and organisation goal?

8. KNOWLEDGE MANAGEMENT (LESSONS LEARNED)

Knowledge management is a process of capturing, recording, transfering and implementing the solutions that evolve as a result of high level of reasoning and problem solving.

How frequently do you think the projects executed or being executed are identifying, implementing and using the lessons learned in project execution?

- ( ) Continuously
- ( ) Occasionally
- ( ) Only When there is a need
- ( ) Rarely
- ( ) Never
- ( ) Other:

Do you receive adequate support from the organisation to identify, implement and use the lessons learned program?

- ( ) YES
- ( ) NO

- SOMETIMES YES; SOMETIMES NO
- Other:

According to you are the lessons learned getting converted into best practices or procedures?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Is there a dedicated team to identify and implement the lessons learned in project execution?

- YES
- NO
- MOST OFTEN
- RARELY
- Other:

Grade the culture of lessons learned process or knowledge management in your discipline/project?

	1	2	3	4	5	
LOW						HIGH

If there are any tools available to register and transfer lessons learned into action, then Scale the efficiency of the tools?

	1	2	3	4	5	
LOW						HIGH

According to you, what are the potential challenges faced in implementing lessons learned process to the project and organisation ?

- Resource Constraints
- Consumes Time

- [ ] Not a Priority
- [ ] Dont see Significant Value in Lessons Learned
- [ ] No data is Available to register Lessons Learned
- [ ] Employee Motivation
- [ ] No Incentive
- [ ] Other:

Submit