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Effective Utilization of Historical Data to Increase Organizational Performance: Focus on Sales/ Tendering and Projects

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ABSTRACT

In Oil and Gas industry there was not enough focus on this topic as cost was not a big factor in good olden days. But the sensational drop in oil prices below US$40 per barrel at the end of 2015 made the price more than 60 percent down compared to the one in previous years. It's clear that the sector is going through one of the most transformative periods in its history. This situation has created more challenges to all O&G company leaders by forcing them to change their business strategies.

The operating companies in the Oil and Gas industry have been focusing to reduce costs and increase organizational performance. Accordingly suppliers companies need to acknowledge their focus on the efficiency and optimization of resources to be able to sustain and grow in a competitive market. It demands better control of estimates and cost on future sales/tendering process. As quoted by one of the Operations Managers "An informed organization saves cost and wins faster". The only way to get reliable information for any organization is by analyzing 'what happened in the past' and what we learned from it. In other words this is achieved through utilization of historical data from previous projects and by developing benchmarking metrics. Further, usage of the historical data can improve estimation and scheduling, support strategic planning, and improve the organizational processes.

The historical project data or information can help in making strategic business decisions in any Organization. It can play a significant role in providing very distinct advantage over the competitors. Historical data can help the management to decide what projects are right for the future of the company and which projects can be avoided. Further, it can help to learn from past mistakes and win future bids by not repeating them. Most of the top management understands the importance of having and using historical project information or data. The problem is that very few companies have the methodologies, procedures, and systems in place to effectively use this information to improve their project processes and to support the estimation, scheduling, and control of future projects (opportunities).

The present work focuses on historical data, estimation process and lessons learned for enhancing organizational performance. Further, the work includes a case study and number of expert interviews conducted at ABB.

The work discusses how to collect, normalize, and analyze historical project data to develop practical information. Three models have been developed for project estimation process with a feedback loop, Lessons learned process model and Historical data utilization process. The recommendations have been made to use the historical data for establishing references for the sales/tendering department for future estimates, which can reduce the dependency on manual or a single person's judgment and improve the estimation process. Some suggestions have also been made for establishing lessons learned process which can improve organizational performance.

The results from analysis show that by applying the recommended processes, organizations can achieve efficiency through easy access and storage of historical database, easy access to lessons learned, measurable KPIs. Also use of key variables like project complexity and severity of requirements for estimation process and historical data process can form a better relation for data analysis and utilization.

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I am very grateful to my thesis advisor **Professor**. **Jayantha.P.Liyanage**, Ph.D., Professor & Chair, Centre for Industrial Asset Management (CIAM), Faculty of Science & Technology, University of Stavanger. The door to his office was always open whenever I ran into a trouble or had a question about my research or writing. His knowledge, understanding about industry, ability to put questions which can generate a thought process in the mind helped me a lot throughout this work and the master studies.

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Finally I would like to thank all my friends and relatives for understanding and accepting my prolonged absence due to the heavier workload and pressure.

DEDICATION

Dedicated to

my father and teacher Sri. ***Mangalampalli Narayana Rao***

my mother Srimathi. ***Mangalampalli Venkata Sitamaha Lakshmi***

who taught me being humble, responsible and the importance of hard work.

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ABBREVIATIONS

AACE	Association for the Advancement of Cost Engineering
BU	Business Unit
CRISP-DM	Cross Industry Standard process for data mining
CTR	Cost, Time, Resource
EDMS	Electronic Document Management System
EFQM	European Foundation for Quality Management
EPC	Engineering, Procurement and Construction
ERP	Enterprise Resource Planning
ESS	Employee Self Service
EVM	Earned Value Management
FEED	Front End Engineering Design
HSE	Health Safety Environment
HW	Hardware
IDRC	International Development Research Centre
IMS	Integrated Management System
IT	Information Technology
KPI	Key Performance Indices
NASA	National Aeronautics and Space Administration
OE	Organizational Efficiency
OGC	Oil, Gas and Chemical
Opex	Operational Excellence
OPQ	Occupational Performance Questionnaire
PA	Process Automation
PCDA	Plan, Do, Check, Act
PM	Project Manager
PMO	Project Management Office
RED	Relentless Execution Dashboard
RELEX	Relentless Execution
SAP	Systems Applications and Product
SCM	Supply Chain Management
STEP	Statoil Technical Efficiency Program
SW	Software
VOR	Variation Order Request
WBS	Work Breakdown Structure

1 Introduction

1.1 Background

As a result of the weak oil prices, many major projects were put on hold or cancelled from last 2 to 3 years. Many companies are going through a period of downsizing (employee reduction, layoffs and early retirements). The operators in the oil and gas industry have been focusing to reduce costs and increase organizational efficiency. For example, Statoil has introduced two programs called STEP 2 (Statoil Technical Efficiency Program) and OE (Organizational Efficiency) which focus not only on Statoil's own organization but also extending it to supplier's processes, efficiency and standardization. By using this program Statoil planned to achieve USD 1.7 billion savings by the end of financial year 2016. So suppliers like ABB need to resonate to increasing demands from their customers by shifting their focus on the efficiency and optimization which are factors of organizational performance to be able to sustain and growth in a competitive market.

It is known that in today's competitive environment it is necessary to deliver projects on time and within budget. There have been requests from customers to reduce man-hour rates of suppliers. But reducing the hourly rate might affect supplier's margins and sustainability. So there is a need to find smarter ways to increase the efficiency and create value to the customers without reducing the hourly rate. This requires retrospection of successful projects executed over a certain period and extraction of lessons learned, which help to streamline ABB's offerings and get better control over estimates on future tendering process. The efficiency and optimization can be achieved by referring to historical data from previous projects which can further increase organizational performance.

It appears that very little historical data from previous projects is used as the basis to develop benchmarking metrics for the future estimations and decisions. The project's historical data and bid history is generally obtained from the knowledge of expert personnel. However no organization can solely depend on this information. The present market situation is causing a tremendous loss of organizational experts in the industry. When any organization needs to downsize it needs to leave these experts. Then all data of vitally important information and lessons learned is typically lost. So every organization needs to properly collect, analyze, and store the historical data in every phase of the project for future use.

Although a lot of attention has been paid to project cost estimation since 1960, making an accurate effort and schedule estimation is still a challenge. In order to identify potential areas of improvement in effort estimation, it is important to investigate the accuracy and method of estimation used and the factors influencing the adoption of estimation methods in current industry. Hamdi & Vince (2001) also states that the first step towards the achievement of project's delivery on time and within budget is to have effective estimation methods in producing realistic project estimates which are the basis of a project plan. Unfortunately, the capabilities of traditional estimation methods are limited.

Based on several surveys by reserchers, inaccuracy in project planning and estimation were identified as major cause for project overrun and delays (Thamhain & L.D., 1986). This is because of the limited capabilities of traditional estimation techniques such as work breakdown structure and network techniques (CPM, PERT) in producing realistic estimates for project effort and duration (D.J.Leech, 1972). The existence of such problems in the present market era of "shrinking" has made the need for sound estimation methods than ever before. The emphasis should be first directed to improve the accuracy of effort estimation. This is because reliable estimation of effort is a necessary prerequisite for developing reliable effort estimates and schedule (Adrangi & Harrison, 1987). Unfortunately, only a small amount of research has dealt with the issue of effort estimation models in oil and gas industry.

In summary, based on above discussion the important areas that have to be focused are historical data, estimation methods and lessons learned for enhancing organizational performance. These have been discussed in detail in following sections as part of the current thesis work.

1.2 Problem Definition

The motivation for the present task of thesis work is when author faced challenges in performing project estimate for design projects of oil and gas related. The challenges have also been faced by sale team and other involved personnel in estimation of projects executed earlier. The challenges are mainly availability of historical data and its credibility for effective utilization in projects future estimation and execution with main focus on improvement on organizational performance.

1.2.1 Organizational Performance

One common strategy for improving organizational performance for an organization is to obtain more business from existing customers and attract new customers by increasing the number of products it offers or offering them better quality with less cost (Gereth, 2013). The organizations need to measure its own productivity on past projects, to know how the organization is performing, how a current project performance differs from that of previously executed projects. There shall be a benchmarking between projects which is missing in several organizations.

One of the key features for achieving the organizational performance is the requirement management skills in design projects i.e., the ability to plan, organize, direct, coordinate, and control. Service and design projects are characterized by a lack of easily measurable items that can provide data for the estimation of effort, duration, and feedback on performance.

1.2.2 Project Estimation

A project might appear to be successful if it meets the official budget or provide more margins than expected. But it does not mean that all the organization functions are delivered as promised. Certainly most of the organizations do not have a mechanism to verify these promises. Then it is a mistake to claim that the estimates are correct. When only some of the functions are delivered, the expected benefits cannot be harvested, and then it can destroy the organizational performance.

As mentioned before, organizational performance requires better control over project estimates. A customer may require a detailed cost estimate to confirm the cost status of a project or to explain comprehensively where and why costs have changed. Customers demand that suppliers manage project costs and meet budgets without compromising excellence in design.

Michael (2003) explained, "Today's customers expect their suppliers to manage project costs in an accurate and responsible manner. They expect that an accurately defined budget is prepared early phase of the project. The entire project scope is executed by meeting all expectations of quality and performance. The customer do not expect to see any extra costs during the execution stage of the project". Abran (2015) has stated, "Project effort estimation is not all about coming up with a magic number to which everyone must commit at the exposure of their professional career, which may lead to staff members spending lots of overtime attempting to meet unrealistic deadlines". Many organizations fail to learn from their mistakes, and do not record data which could help them become less dependent of human judgment. As statistical data rarely is available, expert judgment is most frequently used (Rowe & Wright, 2001).

Therefore, there is a potentiality to work much more efficient in the sales process of estimating projects. The potential is to:

- Extensively reduce the time required for preparation of new tenders.
- Increase quality of estimates.
- Obtain a reliable database to be utilized both in execution and sales for project benchmarking.

1.2.3 Historical Data

Most of the top management understands the importance of having and using historical project information or data. The problem is that very few companies have the methodologies, procedures and systems in place to effectively utilize this information for improving their project processes and supporting the estimation, scheduling and control of future projects (opportunities).

According to Rowe & Wright, (2001), the best way to estimate is to use previously recorded data from a similar projects. There has been lot of research performed on utilizing the historical data for future estimations in Software industry. The researchers continue to develop increasingly complex estimation models and techniques in pursuit of 'accurate' estimates every day. There are several estimation tools offered on the web, for which there is little or no documented evidence on how these tools have performed on completed projects. In addition, there is not much research performed on this topic in Oil & Gas industry.

Project execution personnel report hours on specific activity codes (WBS) in their time sheet registers. These activity codes represent actual work within the project. The data of registered hours of the given activities is part of the historical data, but there is no consistency with these activity codes from project to project. Hence the comparison and analytical foundation of the codes are lost. Also, some of the time sheet registration tools do not have built-in functionality to analyze and do not provide user-interface.

1.2.4 Lessons Learned

Projects Lessons learned can also be considered as historical data used for organizational performance. All organizational process assets are used as inputs for the Plan Stakeholder Management process. Of these, lessons learned database and historical information are of particular importance, because they provide insights on previous stakeholder management plans and their effectiveness. Lessons learned can be used to plan the stakeholder management activities for the current project (PMBOK, 2008).

Through collection of data of Lessons learned and development of own set of capabilities for analyzing that data, the organizations have developed the following

- A key competitive advantage in market oriented organization (Abran, 2015)
- A key credibility advantage in organization in noncompetitive contexts (Abran, 2015)

Project's lessons learned data is collected as part of the project management procedures. But in many organizations it is very hard to find when the data is necessary. Most of the times the focus in lessons learned is only on commercial issues where as the technical issues are not given any importance.

1.3 Objectives

The discussed problems generated the following questions in authors work.

- How to establish benchmarking metrics?
- How to reduce the time required for preparation of new tender?
- How to increase quality of estimates?
- How to obtain historical data?
- How to store this data for being more useful for future?
- How to use this data for organizational performance?
- How to utilize the lessons learned data from projects?

The answers to above questions turned as scope of work and objectives of this thesis work. To achieve organization performance any organization requires:

- Methodology to utilize the historical data (effort data, lessons learnt).
- Proposal for estimation process with feedback loop which uses the historical data.
- Improvements for sales/ tendering process by utilizing the historical data.
- Proposals for improvement areas of KPIs dashboards for organization's performance.

The objective of the thesis is achieved based on the following scope of thesis work and established as the following phases of work:

- Familiarization
- Data gathering & Interviews
- Data Analysis & Recommendation

Familiarization:

- To review articles and books to find out the appropriate models and processes used for estimations and organizational performance.
- To identify and establish baseline knowledge about the different process and activities undertaken in the departments of sales/ tendering and project management.
- The gain necessary knowledge for preparing questionnaire, conduct the face-to-face interviews and the survey.

Data collection & Interviews:

- To formulate a questionnaire for conducting interviews in ABB
- To conduct interviews with managers covering the topics of historical data, project management and sales/ tendering.

Data analysis & Recommendations:

- To develop models and perform analysis for checking how the existing processes are designed and functioning; what the improvement areas are etc.
- To propose recommendations for improvements in estimation process, lessons learned process, historical data utilization process, KPI's to improve organization performance.
- To present summary of thesis work, conclusions and future work.

1.4 Methodology

The methodology in this study follows pragmatic beliefs that uses diverse methods, which could provide the best way to obtain knowledge to solve the problem and are often associated with mixed methods research. The pragmatic approach attempts to validate all participatory variables in a solution to a moral problem (Tashakkori & Teddlie, 2003). Pragmatism dictates both that theory is necessary to any practice and that what we discover in practice must feed back into and modify our initial theories.

This thesis work follows a research process illustrated in Figure 1-1. The study started with identifying the problems in the organizations. The author has realized that the project historical data is not used properly. So number objectives have been generated after going through some processes and tools. The literature has been reviewed and theoretical models were studied. An interview questionnaire was prepared to collect the information through case study. The challenge during this phase is to find relevant literatures from different authors as the subject chosen is broader scope and not much previous research on this topics.

The author has developed models for estimation process with a feedback loop, lessons learned process and historical data utilization process. These are the generic models which can be used by any organization. The challenge during this phase is to connecting different topics discussed in theory and preparing the model.

A case study has been performed in ABB to gather the organizational data for validating the theoretical models. In addition, the author also conducted number of interviews and interactions with the experts to assess the present situation in ABB. The interview results are intended to use to support the assumptions made for development of models and to propose the recommendations based on the predictions from the models.

The interviews were targeted to the expert management group mainly Project managers, Engineering Managers, and Sales/Tendering managers. As the present research main focus is about improving organizational performance, the interviewees need to have overall knowledge of all the processes within the organization ABB. Accordingly, the above proposed expert group typically has knowledge of the organizational processes, tools, project history.

Totally 12 interviews have been conducted containing *Eight* project managers, *Two* engineering managers and *Two* sale/tendering managers. All of the interviewees have more than 20 years' of experience. The interviews were very challenging and the interaction needs in-depth knowledge of theory and practical knowledge of the author. The interviews were started with introduction of the project and project goals. A mind map diagram was prepared to explain about the research and it goals, so that the interviews will not be deviated from the research topic. Each interview lasted for minimum 90 min and some of them extended to 120 min.

The validated results from the models, interviews and case study have been discussed and finally improvements and conclusions were presented. Considering the feedbacks from interviewees and case study in ABB into theoretical model is very challenging as it is hours of brain storming.

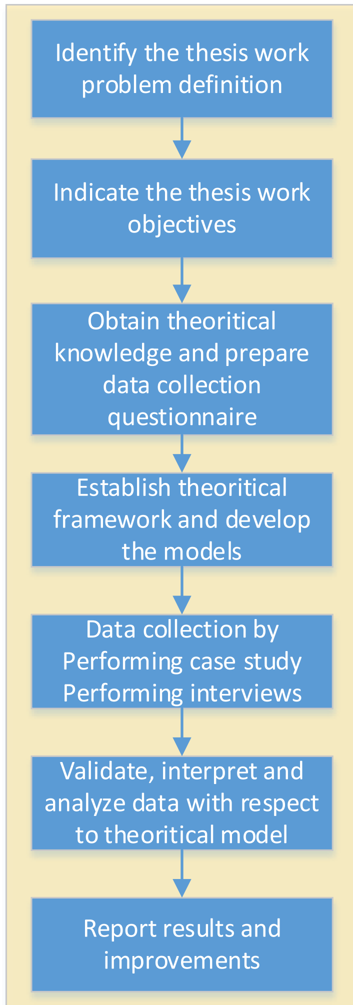

Figure 1-1 Thesis work methodology

1.5 Summary of Thesis

Figure 1-2 illustrates outline of present thesis work and depicts all the chapters and their sub topics.

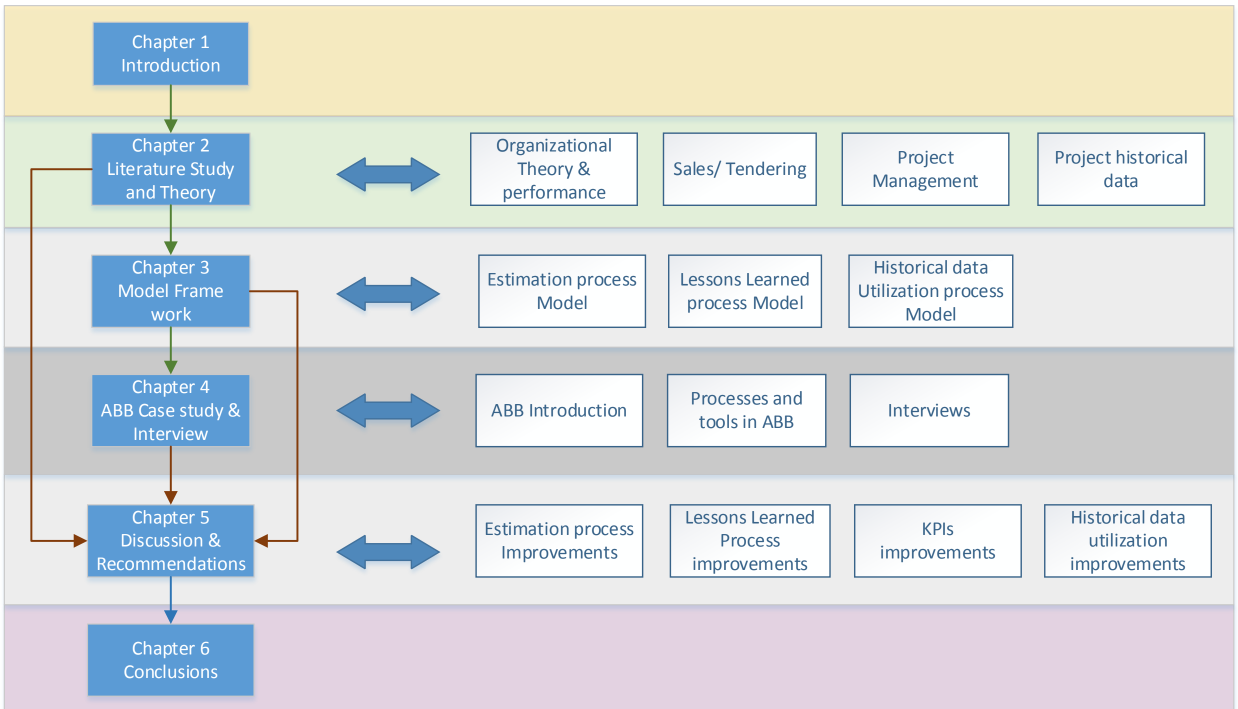

Figure 1-2 Thesis approach illustration

Chapter1: The chapter defines background, problem definition and objectives of the thesis work. It discusses organizations' understanding of importance of having and using historical project information or data and about its handling. The limitations and assumptions of the present work are also addressed.

Chapter2: The chapter provides theory and review of literature related to Organizational theory, Estimation methods, Organizational performance measurement, Project complexity definition, Work breakdown structure (WBS), Estimation methods and Historical data. The chapter deals with necessary existing process models used in the fields of organizational performance, sales and project management, and their advantages and disadvantages.

Chapter3: In this chapter, the author has developed models for estimation process with a feedback loop, lessons learned process and historical data utilization process. The generic models which can be used for any organization are developed based on the work from previous literature. Modification of models and necessary adjustments made to suit to Oil and Gas industry are discussed. Each phase of the models has been analyzed in detail and the roles and responsibilities for individual phases have been defined.

Chapter4: This chapter introduces the case study conducted in the company ABB. The chapter starts with an introduction and organizational structure of ABB. Subsequently the chapter defines the existing practices, processes and tools used in ABB. The sales processes, estimation models, complexity of project definition, historical data format and KPIs used in ABB are also explained. The chapter also provides details of the interviews from experts like project manager (PM), Engineering Manager (EM) and Sales/Tender Manager (SM) in ABB. Further it provides the structure of the questionnaire of interviews to cover topics of the Organizational and Project performance, Sales/Tendering and Historical data. The interview results gathered from diverse topics are presented.

Chapter5: The chapter discusses the results from the interviews and case study in ABB by using the developed models described in chapter 3. The selected phases of the models are validated and discussed against data from the interviews and case study. It also includes validation of models. Based on the results from present work, the improvements and recommendations proposed for organizational performance are discussed.

Cahpter6: The chapter presents conclusions and future work from the present thesis work.

1.6 Limitation and Assumptions

- The case study for thesis work was confined to organization ABB which is supplier for SAS (Safety Automation system) and Control system related projects in Oil and Gas industry.
- The thesis is limited to only supplier organization and does not include their customers or subcontractors. So the work presents supplier point view rather than customers point of view.
- The study focuses mainly on formal organizations for which the main aim is produce goods and services.
- The thesis work mostly focuses on initial estimation of the project. During the project execution there might be some deviations in the scope, deliveries and schedule which effects the initial estimations. The estimation might need to be adjusted according to these requirements. These things are not considered in the estimation process.
- The change of technology in oil and gas industry is very fast. So theoretically the models and methodologies might be applicable today, but the rapid change in the technology and respective time have to be considered in developing the tools, models and methods.
- The author was not able to disclose certain data because of the confidentiality and the nature of the study is very sensitive for business.
- The study concludes based on the data from 5 Green/Brown field projects and interviews from selected number of people.
- The author assumed that the responses from interviews are reliable.

2 Literature Review and Theory

This chapter provides theory and review of literature related to Organizational theory, Estimation methods, Organizational performance measurement, Project complexity definition, Work breakdown structure (WBS), Estimation methods and Historical data. The chapter deals with necessary existing process models used in the fields of organizational performance, sales and project management, and their advantages and disadvantages.

2.1 Organizational Theory

An organization is an entity comprising multiple people, such as an institution or an association that has a collective goal. Business dictionary has defined "Organization is a social unit of people that is structured and managed to meet a need or to pursue collective goals. All organizations have a management structure that determines relationships between different activities, members, subdivisions and assigned roles, responsibilities, and authority to carry out different tasks." (Business Dictionary, 2016)

The history of organizations is present since the history of mankind exists. Our modern society and its rapidly developing complex technology that result in the specialization of experts in very narrow fields is the main reason for the existence of organizations (Shtub & Karn, 2010). The most products and services today are based on the integration of hardware, software, data and human expertise, which a single person usually does not fully master on all of them in combination. So the organizations in the form of expert teams are created to compete in today's markets.

There is a difference between formal and informal organizations. Most formal organizations are based on a clear definition of responsibility, authority and accountability, while informal organizations are based on common interests, common beliefs, social values, feelings, tradition, etc. (Shtub & Karn, 2010). Wherever the term 'Organization' is used in this thesis work it means the formal organizations for which the main aim is to produce goods and services.

2.1.1 Organizational Functions

In order to produce and sell their product or service, most organizations need to undertake 6 key functions:

- Design and Production
- Finance
- Human Resources
- Sales and Marketing
- Administration
- Research and Development.

Each of these functions needs to work together and communicate so that the whole of the organization has the same aims and objectives. Achieving this communication across the various functions is key activity. A starting point for this type of communication is the creation of a clear set of company objectives which each function is aware of. These objectives then need to be further broken down into specific objectives for each function. Shtub & Karn, (2010) concludes that regular reviews shall be carried out on the following things to ensure that the whole company is pulling towards its objectives.

- How each function is performing against its objectives?
- How the company is performing against its overall objective?

2.1.2 Organizational Structure

Bloisi & Cook (2007) define organizational structure as a grouping of people and tasks into different units to boost coordination of communication, decisions, and actions. It is essential to realize the close connection between the different units within the organizations and it makes easier to understand the complex task of directing an efficient organization. Just like a chair, all of organization units or functions must be of the right type and placed in the right location so that the entire system works well together.

The organizational structure defines the relationship and interactions between the units of the business, and identifies how the chain of command runs through the different levels. The Organization structure can be formed based on organizational functions. The functions and structure influence each other. Sisney (2012) believes that sound organizational structure will make it unarguably clear what each function (and ultimately each person) is accountable for. In addition, the design must both support the current business strategy and allow the organization to adapt to changing market conditions and customer needs over time.

Gereth (2013) created a Building Block of differentiation for organizational structure. Figure 2-1 explains the basic philosophy used for organization structure in most of the organizations. In an organization people with similar and related roles are grouped into a subunit. The main subunits that develop in organizations are department or divisions. A function is composed of a group of people working together, who possess similar skills or use the same kind of knowledge, tools, or techniques to perform their jobs.

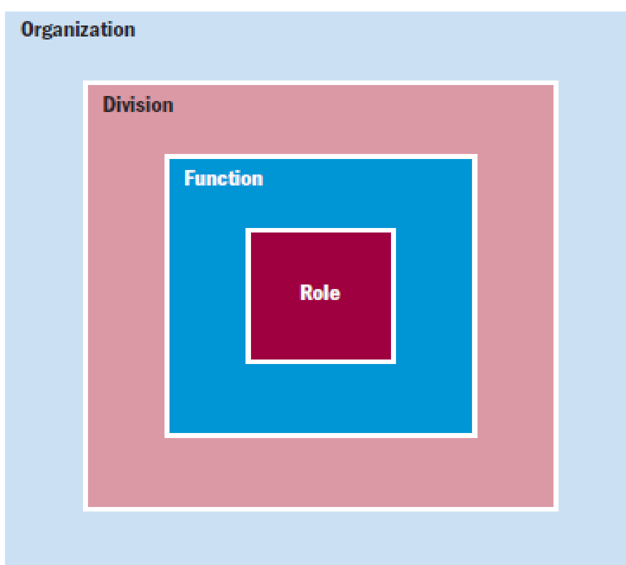

Figure 2-1 Building Block of Differentiation (Adapted from Gareth, 2013)

2.1.3 Organizational Operations

Improving the organizational performance having good tools and processes is just not enough. The organizations shall have operations department to look after the processes, tools, etc. Further operations make decisions related to optimization.

An organizational operation is one of the three strategic functions of any organization while the other two are Marketing and Finance. Operations' decisions include decisions that are strategic in nature meaning that they have long-term consequences and often involve a great deal of expense and resource commitments. When the organization makes good decisions of operations, it will be able to produce affordable, functional, and attractive services to customers.

Strategic decisions of operations include the following: (Boundless, 2016)

- Facility location
- The type of technologies that the organization uses
- Determining how employee and equipment are organized
- How much long-term capacity the organization provides to meet customer demand
- Future competitiveness
- Standardization
- Operational excellence

Tactical decisions of operations have short to medium term impact on the organization. These often involve less commitment of resources and can be changed more easily than strategic decisions. The following are some tactical decisions:

- Workforce scheduling
- Establishing quality assurance procedures
- Contracting with vendors
- Managing inventory

Strategic and tactical operations decisions determine how well the organization can accomplish its goals. They also provide opportunities for the organization to achieve unique competitive advantages that attract and keep customers.

Operations management is a multi-disciplinary field that focuses on managing all the aspects of the business's operations. A typical organization has integrated with many operational activities (Jay & Barry, 2014). The foremost operation functions get along with the latest technology and techniques, improve productivities, reduce cost and flexibly meet the customer need in changing environment. In an organization they work to develop the plan and strategy to cope with new challenges and opportunities to meet in particular environment.

Operations management transforms inputs (labor, capital, equipment, land, buildings, materials and information) into outputs (goods and services) that provide added value to customers. Figure 2-2 summarizes the transformation process. The arrow labeled "Transformation System" is the critical element in the model that determines how well the organization produces goods and services that meet customer needs. All organizations must strive to maximize the quality of their transformation processes to meet customer needs.

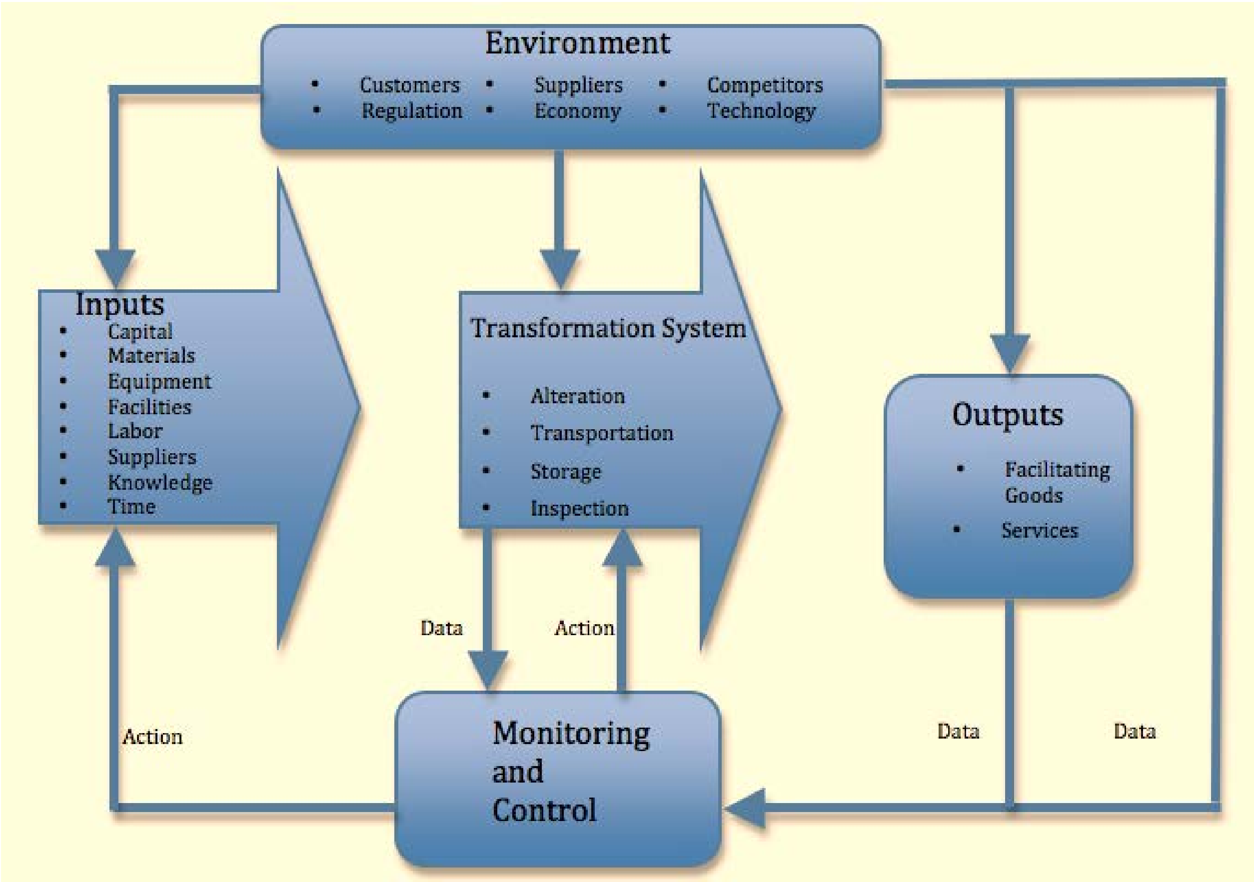

Figure 2-2 Typical transformation process by operation management (Adopted from Boundlesss, 2016)

2.2 Organizational Performance

The analysis of organizational performance is a crucial step in the organizational assessment process. Yet, measuring performance is one of the most problematic issues in the field of organizational theory (Charles, et al., 1999). While there are a number of approaches to assess organizational performance, there is little consensus about what constitutes a valid set of criteria.

Organizational performance comprises the actual output or results of an organization measured against its intended outputs (or goals and objectives). Organizational management processes focus on efficiency i.e. reducing time and cost (Jon Vom & Michael, 2010). However most of the times organizations tend to be in comfort zone by following the way the things have been done before. This tendency pulls back going ahead to take the challenges for improving the organizational efficiency. As described by Rear Admiral Grace Hopper (1906-1992), the most dangerous phrase in the language is “We’ve always done it in this way”.

Organizations for being effective must continuously change themselves and adjust to internal and external requirements. They must also respond to technological change opportunities and the resulting challenges (Frankel.E.G, 2008). Technology more than ever affects organizations, how they work and how they are structured. It facilitates the operations and working of organizations by improving the communication & understanding within and outside the organization.

Also organizations, to be effective, must continuously aim at increasing value. This can be achieved by improving the value of work managed by the organization, by increasing the productivity of individuals or processes, by rearranging or joining processes, and by eliminating unnecessary functions, operations, investment and more (Frankel.E.G, 2008).

Organizations use technology to become more efficient, more innovative and to meet the needs and desires of stakeholders. Each department or function in an organization is responsible for building competences and developing technology that allows it to make a positive contribution to organizational performance. When an organization has technology that enables it to create value, it needs a structure that maximizes the effectiveness of the technology (Gereth, 2013).

Any organization can directly relate its performance based on the sales where a purchase comes in and projects where the services or products are delivered. The operations have overall control over the processes, coordination, and communication between these departments.

In recent years, many organizations have attempted to manage organizational performance using the balanced scorecard methodology where performance is tracked and measured in multiple dimensions. The operating organization establishes and owns metrics and dashboards, and visual performance management is utilized to drive day - to - day performance optimization.

In order to achieve maximum organizational performance, the organizational process assets need to be effectively utilized. The important organizational process assets are the plans, processes, policies, procedures, and knowledge bases which are specific to and used by the performing organization. They include any artifact, practice, or knowledge from any or all of the organizations that can be used to perform or govern the project. Of these, the key process assets are organization's knowledge bases such as lessons learned and historical information. According to PMBOK (2008), the organizational knowledge base includes:

- Configuration management knowledge bases containing the versions and baselines of all performing organization standards, policies, procedures, and any project documents;
- Financial databases containing information such as labor hours, incurred costs, budgets, and any project cost overruns;
- Historical information and lessons learned knowledge bases (e.g., project records and documents, all project closure information and documentation, information regarding both the results of previous project selection decisions and previous project performance information, and information from risk management activities);
- Issue and defect management databases containing issue and defect status, control information, issue and defect resolution, and action item results;
- Process measurement databases used to collect and make available measurement data on processes and products; and

- Project files from previous projects (e.g., scope, cost, schedule, and performance measurement baselines, project calendars, project schedule network diagrams, risk registers, planned response actions, and defined risk impact).

There are three main techniques to evaluate organizational performance. They are,

- Key Performance Indices
- Benchmarking
- Critical Success Factors

The motive of all these techniques is to increase performance of the organization and achieve objectives.

2.2.1 Key Performance Indices

A Key Performance Indicator (KPI) is a measurable value that demonstrates how effectively an organization is achieving key business objectives. Organizations use KPIs at multiple levels to evaluate their success at reaching targets. High-level KPIs may focus on the overall performance of the organization, while low-level KPIs may focus on project progress, processes in departments such as sales, marketing, etc.

KPI is also known as key success indicators. It is helpful to measure company progress towards the setting goals and set objectives as well. When an organization has analyzed its mission, and identifies about stakeholders and defines the goals, it measures its development.

Selecting the right KPIs will depend on the organizations strategy and business interest. Each organization function uses different KPIs to measure success based on specific business goals and targets. To find out what types of key performance indicators are relevant to organization and its functions is an important and challenging task.

Once organizations select their key business metrics, they can track these KPIs in a real-time reporting tool. KPI tracking can be done using dashboard software and giving the entire organization insights into current performance.

'What is important' often depends on the department which is measuring the performance - e.g. the KPIs that are useful to finance differ from the KPIs assigned to sales. Since there is a need to understand well what is important, various techniques to assess the present state of the business is required, and also its key activities associated with the selection of performance indicators. These assessments often lead to the identification of potential improvements. So performance indicators are routinely associated with 'performance improvement' initiatives. A very common way to choose KPIs is to apply a management framework such as the balanced scorecard (Slack & Lewis, 2002). The details of balance score card are discussed in Section 2.2.1.1

Evaluation of organizational performance that is very important to the growth and improvement of the organization also focuses on the productivity, effectiveness and efficiency. Any organization’s performance measurements must be based on the following five performance objectives. (Slack & Lewis, 2002). The organizational performance objectives are depicted in Table 2-1.

Performance Objectives	Aspects	Description
Cost	Low	The ability to produce at low cost
Quality	Best, No Error	The ability to produce in accordance with specification and without error.
Speed	Quick response, Fast response	The ability to do things quickly in response to customer demands and thereby offer short lead times between when a customer orders a product or service and when they receive it.
Dependability	Promising delivery , Customer satisfaction	The ability to deliver products and services in accordance with promises made to customers.
Flexibility	Change Operations according to market	• The ability to change the volume of production. • The ability to change the time taken to produce. • The ability to change the mix of different products or services produced. • The ability to innovate and introduce new products and services.

Table 2-1 Organizational performance objectives

The characteristics of KPIs are that KPIs have to be (Parmenter, 2007):

- Agreed upon by all parties in the organization functions
- Meaningful to the intended audience
- Quantifiable measurements that can be shared and analyzed across organizational divisions at any time
- Regularly measured
- Directed toward the benefits the organization and the projects
- A basis for critical decision-making throughout the project
- Aligned with objectives
- Realistic, cost-effective and tailored to the organization’s culture, constraints and time frame
- Unified with organizational efforts
- Reflective of an organization’s success factors
- Specific to the organization and the particular project

2.2.1.1 Balanced Score Card

As already mentioned the balanced scorecard management framework is a usual method to choose KPIs. This technique is originated by Dr. Kaplan & David Norton. It is very helpful to manager to more focus on balanced view the organization performance.

The balanced scorecard is a strategic planning and management system that is used extensively in business and industry, government, and nonprofit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals (Kaplan & Norton, 1996). It is a performance measurement framework that added strategic non-financial performance measures to traditional financial metrics to give managers and executives a more 'balanced' view of organizational performance. It provides a framework that not only provides performance measurements, but helps planners identify what should be done and measured. It enables executives to truly execute their strategies.

The balanced scorecard is a management system (not only a measurement system) that enables organizations to clarify their vision and strategy and translate them into action. It provides feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results.

The balanced scorecard views the organization from four perspectives as shown in Figure 2-3, to develop metrics, collect data and analyze and to monitor the performance or progress towards organizational objectives. These perspectives are customers' prospective, internal business process, finance, and learning & growth.

The factors affecting each perspective are shown in the Figure 2-4.

The Customer Perspective: Recent management philosophy has shown an increasing realization of the importance of customer focus and customer satisfaction in any business. These are leading indicators: if customers are not satisfied, they will eventually find other suppliers that will meet their needs. Poor performance from this perspective is therefore a leading indicator of future decline, even though the current financial picture may look good.

In developing metrics for satisfaction, customers should be analyzed in terms of kinds of customers and the kinds of processes for which we are providing a product or service.

The Business Process Perspective: This perspective refers to internal business processes. Metrics based on this perspective allow the managers to know how well their business is running, and whether its products and services conform to customer requirements (the mission). These metrics have to be carefully designed by those who know these processes most intimately.

The Financial Perspective: For most businesses the challenges are to shift a focus from financial perspective only to the customer, internal and learning and growth perspectives. Timely and accurate funding is always a priority, and managers will do whatever necessary to provide it. But the point is that the emphasis on financials leads to the "unbalanced" situation with regard to other perspectives.

The Learning & Growth Perspective: This perspective includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. In a knowledge-worker organization, people, the only repository of knowledge, are the main resource. In the current climate of rapid technological change, it is becoming necessary for knowledge workers to be in a continuous learning mode. Metrics can be put into place to guide managers in focusing training funds where they can help the most. In any case, learning and growth constitute the essential foundation for success of any knowledge-worker organization.

Kaplan and Norton (1996) emphasize that 'learning' is more than 'training'; it also includes things like mentors and tutors within the organization, as well as that ease of communication among workers that allows them to readily get help on a problem when it is needed.

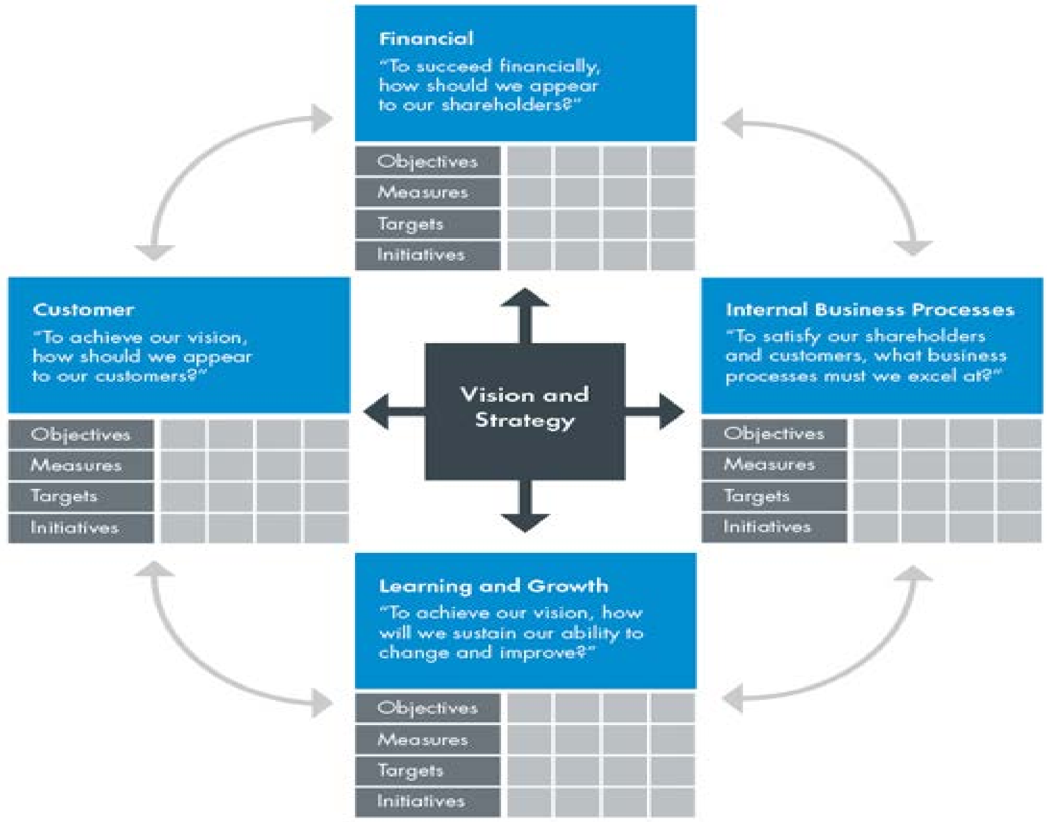

Figure 2-3 Balanced Score card framework (Adapted from Kaplan and Norton, 1996)

Figure 2-4 Balanced score card perspectives

2.2.2 Benchmarking

Abran (2015) defined "Benchmarking is the process by which measurement results of a specific entity are compared with those of similar entities".

Benchmarking for an organization involves:

- Comparing its performance against the performance of other organizations development.
- Comparing its internal project performance against the other successful project in organizations.
- Identifying best practices that led to those higher levels of performance.
- Implementing the best practices with objectively demonstrated higher performances within own organization (Abran, 2015).

Benchmarking is typically based on the following key concepts:

- Comparison of relevant characteristics of the products and service.
- Comparison of quantitative and documented evidence of the performance of the production process and/or service delivery.
- Identification of the best practices that have demonstrated a continuous ability to deliver superior products and services (Abran, 2015).

There are 2 types of Benchmarking categories: Internal and External

Internal Benchmarking: This type of benchmarking is performed within an organization.

- For instance the productivity of a current project can be compared with the productivity of the projects completed within the organization.
- If an organization has multiple development groups, the comparison can be performed across various groups within the organization.

External Benchmarking: This type of benchmarking is typically performed with other organizations, within a geographical area in a specific market. This includes Competitive and Functional benchmarking.

- Competitive Benchmarking: This type of benchmarking is performed by collecting data about direct competitors, comparing direct quantitative performance, and then analyzing the causes of variations, which lead to identification of best practices. Generally competitors do not provide that kind of sensitive data. So this benchmarking is difficult.
- Functional Benchmarking: When direct competitive benchmarking is not an adoption or risky, functional benchmarking can be carried out with organizations delivering similar or related services in different markets.

2.2.3 Critical Success Factors

Critical success factors are those elements that must go well to ensure success for an organization or for a manager. These factors represent those managerial or organizational areas that must be given special and continual attention to bring high performance. Critical success factors influence organization's current operating activities to achieve its future success (Boynton & Zmud, 1984).

Belassi and Tukel (1996) segregated the critical success factors into four areas:

- Factors related to the project (i.e. size, uniqueness, urgency, etc.)
- Project managers and team members (i.e. skills, background, etc.)
- Organization (i.e. management support, structure, etc.)
- External environment (i.e. political, technological, etc.)

2.2.4 Organization Performance Assessment Model

The International Development Research Centre (IDRC) and Universalia Management Group have constructed a framework to help organizations assess themselves. Their approach can help to clarify important issues and guide the collection of data to help organizations make decisions to improve organization's performance and capacity (Charles, et al., 1999).

Organization's performance is made visible through the activities it conducts to achieve its mission. Outputs and their effects are the most observable aspects of an organization's performance. Ideas about the concept of performance vary considerably by each stakeholder inside or outside organization. For instance, administrators might define organization's performance in terms of money, whereas the engineering department measures performance as quality. Charles, et al. (1999) concluded that very few organizations have performance data readily available. However, it is usually not difficult to generate this information from existing data, but it is difficult to develop mechanisms for gathering performance data (Historical data). Data gathering tends to be manual or automatic. It is far more difficult to obtain clarity on the merits of particular performance data and indicators. It is even more difficult to arrive at value judgments regarding acceptable levels of quantity and quality for each performance indicator. The real questions are: How does the organization define good performance? Does good performance help the organization to attain its mission?

Further, the International Development Research Centre (IDRC) defined a frame work to relate Organizational performance to four main elements: effectiveness, efficiency, relevance and financial viability. Figure 2-5 illustrate the elements of organizational performance and their interactions.

2.2.4.1 Effectiveness:

The effectiveness of the organization is the degree to which it moves toward the attainment of its mission and realizes its goals. The basic difficulty in analyzing effectiveness lies in the fact that many organizations make multiple statements about their missions and goals. Effectiveness lies in the fact that how clearly it is communicated throughout the organization.

Effectiveness measures

It’s questionable how effective an organization is in working towards its mission. The important measures for effectiveness is to verify whether:

- The charter, mission statement, and other documents provide the goals of the organization.

- The mission is known and agreed to by staff.
- The mission is operationalized through program goals, objectives, and activities.
- Quantitative and qualitative indicators are used to capture the essence of the mission.
- A system is in place to assess effectiveness.
- The organization monitors organizational effectiveness.
- The organization uses feedback to improve itself.

Indicators for Effectiveness

- Number of clients served
- Quality of services or products
- Environmental friendly changes
- Service access and usage
- Knowledge generation and use
- Collaborative arrangements
- Demand for policy or technical advice from stakeholders
- Growth indicators in terms of coverage of programs, services, clients, and funding

Figure 2-5 Organizational Performance assessment model (Adopted from IDRC model)

2.2.4.2 Efficiency

An organization must be able not only to provide exceptional services but also to provide them within an appropriate cost structure. Performance is increasingly judged by the efficiency of the organization (for example, the quality of the deliveries, the outputs of employee, Cost saving measures). Whatever the overall size of the unit be, performing organizations are viewed as those that provide good value for the money in both quantitative and qualitative terms.

Efficiency measures

It is debatable how efficient is the organization in the use of its human, financial, and physical resources. The efficiency is to verify whether:

- Staff members are used by the organization to the best of their abilities
- Maximal use is made of physical facilities (buildings, equipment, tools, technology, etc.).
- Optimal use is made of financial resources.
- The administrative system provides good value for cost.
- High-quality administrative systems are in place (financial, human resources, program, strategy, etc.) to support the efficiency of the organization.
- Benchmark comparisons are made of the progress achieved in the organization.

Efficiency Indicators

- Cost per client served
- Cost-benefit of programs
- Output per staff
- Employee absenteeism and turnover rates
- Program-completion rates
- Overhead - total program cost
- Timeliness of service delivery
- Quality feedback

2.2.4.3 Relevance

Organizations in any society take time to evolve and develop, but they must develop in ways that consolidate their strengths. Organizations face internal and external crises, and no organization is protected from becoming out of date, irrelevant, or subject to closure. To survive, organizations must adapt to changing contexts and capacities and keep its mission, goals, programs, and activities agreeable to their key stakeholders.

Relevance measures

It is to be measured if the organization has remained relevant. The relevance is to verify whether:

- Regular program revisions reflect changing environment and capacities
- The mission is undergoing review.
- Stakeholder-needs assessments are conducted regularly
- The organization regularly reviews the environment to adapt its strategy.
- The organization monitors its reputation.

- The organization creates or adapts to new technologies.
- Innovation is encouraged.
- The organization regularly undertakes role analyses.

Relevance Indicators

- Stakeholder satisfaction (customers, shareholders etc.)
- Number of new programs and services
- Changes in partner attitudes
- Changes in reputation among peer organizations
- Changes in reputation among key stakeholders
- Stakeholders' acceptance of programs and services
- Support reserved for professional development
- Number of old and new financial contributors (risk of discontinuance, leverage of funding)
- Changes in organizational innovation and adaptiveness (changes appropriate to needs, methods) Changes in services and programs related to changing client systems

2.2.4.4 Financial Viability

The organization's inflow of financial resources must be greater than the outflow to be survived. The conditions needed to make an organization financially viable include multiple sources of funding, positive cash flow, and financial surplus.

Financial-viability Measures

The questions to be asked if the organization is financially sustainable. The measure of viability is to verify whether:

- The organization consistently obtains new projects.
- The organization consistently has more revenue than expenses.
- Assets are greater than liabilities.
- The organization keeps a reasonable surplus of money to use during difficult times.
- The organization monitors finances on a regular basis.
- Capital assets and depreciation are monitored.

Financial viability indicators

- Changes to net operating capital over 3 years
- Ratio of cash to deferred revenues
- Ratio of current assets to current liabilities
- Ratio of total assets to total liabilities
- Growth in terms of amount of resources mobilized, assets, capital, and revenues
- Partners hired to provide services on a regular basis

The organizations performance can be increased by establishing proper key performance indices for all these parameters and monitoring them regularly.

2.3 Project Historical Data

The data became the key asset in modern days. Yet most data is in pretty bad shape, most companies are not very good at putting their data to work. Solving these problems is the management challenge of the 21st century. Redman (2016) consider research firm IDC's estimate of the size of the big data market is: $136 billion per year, worldwide, in 2016. This figure should surprise no one with an interest in big data. IBM's estimate of the yearly cost of poor quality data $3.1 trillion, in the US alone, in 2016. Most of the people who deals with data every day know bad data is so expensive.

Most of us take decisions based on our past experience whether it is personal or business. If we don't have our own history, we ask others about their past experience. The reason to do this is to take advantage of the experience to make better, profitable or efficient decision.

Historical data, in a broad context, is collected data about past events and circumstances pertaining to a particular subject. By definition, historical data includes most data generated either manually or automatically within an organization (Redman, 2016). Historical Information as documents and data on prior projects including project files, records, correspondence, closed contracts, and closed projects.

The business value of historical data forms a Poisson distribution. The Poisson distribution describes the worth of business data over time to the business purpose as shown in Figure 2-6. Hence organizations needs to establish proper infrastructure and processes to utilize the data effectively without the data getting too old.

Figure 2-6 Historical data Poisson distribution

The historical data is usually in the form of daily, weekly or monthly backups. Typically the data is analyzed at the lowest level, depending on the nature of the business. But many the organizations do not know how to analyze and utilize the huge data.

<u>End uses of historical database</u>

The historical project database can be used for many purposes. Primary goals is to improve current practices relating to estimating, cost control, strategic scheduling, and standard project processes. This is done by converting historical project data into a useful knowledge base that can identify deficiencies and highlight areas for improving company's overall performance (Todd & Bruce, 2007).

- Benchmarking: One of the primary benefits of project historical data is to provide benchmarking data, metrics and factors that will be an invaluable aid for reviewing and validating estimates. The estimate review and validation process shall include a benchmarking report that compares ratios and factors from the estimate being reviewed with historical values from similar type projects in the historical database (Todd & Bruce, 2007).
- Database Calibration: The historical data can also be used to check and calibrate the unit cost database. This is especially important during times when resource pricing is volatile. A check of historical database can help to determine if these cost fluctuations are a long term trend or simply a short term spike, allowing to calibrate Unit cost estimating database appropriately (Todd & Bruce, 2007).
- Conceptual Cost Estimating and Scheduling: The historical data can also be used as a cost estimating tool to create conceptual level estimates and schedules that are based on the historical project information stored in the database. The conceptual level estimates can be prepared within minimal amount of time or engineering input. Because these high level, conceptual estimates are based on actual cost data and information from similar projects, the results can be surprisingly accurate (Todd & Bruce, 2007).
- Strategic Project Planning: The historical data can also be used for strategic project planning efforts. By using historical project information related to work breakdown structures, schedule logic, and account coding, the lessons learned from successful and failed projects can be applied during the front end planning sessions for the control of future projects. High level staffing requirements and durations for engineering, construction, start-up, etc., can be approximated by utilizing the historical project data (Todd & Bruce, 2007).
- Customer Relationship: The historical data can be used by sales team for complementing customer relationships. To get the new customer and to retain them, knowing customers historical habits is a very powerful thing. Once one knows how customer is behaving during volatile market it is easy to plan the future trends from them and plan the strategy accordingly.
- Organizational forecasting: The historical data can be used to produce objective factors that can be applied to gross budget forecasts to yield organizational workload and resource forecasting based on technical and performance characteristics of the project backlog.

2.4 Sales/ Tendering

Sales operations are a set of business activities and processes that help a sales organization run effectively, efficiently and support business strategies and objectives. Sales operations may also be referred to as sales, sales support or business operations. Sales and marketing function handles the exchange with customers (Gereth, 2013).

Sales/Tendering is shifting from a model of twentieth century "selling products and services" to a model of twenty-first century, in which salespeople focus on increasing customer productivity and organizational efficiency (Leigh & Marshall, 2001). Piercy (2006) categorizes this change as the emergence of the strategic sales organization, where sales converges with marketing to take on greater strategic significance to the organization.

A sales department has the responsibility for deciding where the company should sell and what its prices should be. This includes choosing any sub suppliers the company uses, such as wholesalers, channel partners etc. This requires a division to research where the company's competitors are selling and what the customers are expecting. To maintain its customer base, sales and marketing takes responsibility for making sure customers are happy as well as trying to upsell them. The division is proactive in contacting customers with surveys and special offers, and is reactive in attempting to solve any problems that might cause the company to lose customers.

So the personnel working with Sales shall have knowledge of firm's long &short-run goals, objectives, processes, customer behavior and competitors. For salespeople to succeed in a service sales process they require knowledge held not just by marketing (unique selling features, value in use, competitive advantage, segmentation, branding) but also by operations (product issues, production scheduling, quality control, R&D, delivery timeliness and reliability), and finance (profit and loss information) resulting in the need for greater internal communication (Leigh & Marshall, 2001).

<u>The following or Functions of Sales to:</u>

- Provide sales tenders in response to customer inquiries.
- Listen to customer needs to plan the necessary means for receiving customer feedback through organizations' internal channels or external channels
- Track trends and monitor competition to know the position of the company with respect to the market and competition.
- Work and transmit brand values creating and disseminating images, messages, ideas, etc that communicate the best brand values. Also ensure that all company departments convey these messages in a consistent and unified way to customers.
- Coordinate efforts with partners to align the efforts of contributors with those of the company.
- Innovate to work on new promotions, affiliate programs, customer retention techniques, improvements in the conversion of their messages and actions, to engage the client.
- Communicate with the rest of the organization to discover new opportunities
- Help to improve sales processes
- Forecast its budget for the next year's activities, stretching it in order to make the most of it.

Regardless of who actually prepares a detailed cost estimate, the design team should be actively involved in the process. Architects will benefit from gaining an understanding of the basic principles and major issues associated with cost estimating. This conceptual knowledge can help architects select and work with consultants who provide these services, and it can be useful in developing in-house cost-estimating capabilities.

2.4.1 Estimation Process

The estimation is the process of predicting the cost of a job or product through quantitative analysis of the work required. Detailed cost estimates can be an important part of overall cost management and budget adherence, although not always required by clients. (Michael, 2003)

The Dictionary Webster, u.d. defines estimation in the following manner: “To form an opinion of, as to amount, number, etc., from imperfect data, comparison, or experience; to calculate roughly.” In the Statistics Glossary, the task of estimation is explained as follows: “Estimation is the process by which sample data is used to indicate the value of an unknown quantity in a population. An estimate is an indication of the value of an unknown quantity based on observed data.” (Valerie & John H, u.d.). AACE International describes cost estimating as the “predictive process used to quantify, cost, and price resources required by the scope of an asset investment option, activity, or project” (AACE, 2016). All of the above definitions explain the importance of the available existing data, and experience of an organization for future estimations.

The cost estimation is the iterative process of developing an approximation of the monetary resources needed to complete project activities. Project teams should estimate costs for all resources that will be charged to the project. This includes but is not limited to: Labor, Materials, Equipment, Services, Software, Hardware, Facilities and Contingency Costs

Any organization needs estimates for project office formulation and implementation phases, source selections, what-if exercises, affordability studies, economic analyses, and Analysis of alternatives, resource as well as for supporting numerous types of decisions related to projects. Based on those analyses organization can decide to undertake the project. Once the decision is made to proceed with the project, cost estimates provide management with critical cost-risk information to improve the control of resources in the present and the future. It also provides the information to project managers about the activities required to complete project and resources required for each activity. A project task definition, scope definition which can be used for project team to understand their role in the project and the overall activities more efficiently are generated by a cost estimate. The cost estimating process must therefore be adaptable and flexible while holding firm to its principles, objectives, and practices of cost estimating (PMBOK, 2008).

Project approval requires estimates to be performed very early in the project life cycle, often before requirements have been clearly specified. The project approval process typically has a number of points where a “go/no go” decision must be made. At each of these points, an estimate may be required to permit management to make the decision (AACE, 2016). Early in the project life cycle, these may be rough order of magnitude of estimates sufficient to allow the organization to determine whether they should continue to look at a project. Late in the project, management can get much more detailed estimates of cost to completion in order to decide whether to cancel an ongoing project.

For managing and understanding a project, an estimate must be done carried out in the development of the project to arrive at an initial estimate, and then repeated on a regular basis during development to keep the estimate current. For these estimates the prime concern is not necessarily the absolute “cost," but the estimated set of tasks required to complete the project, the results of each of these tasks, how these tasks fit together, and the resources required to complete each task.

Re-estimates are required throughout the development cycle regardless of why the estimate is done. As a project progresses, more information is available on the product and the process being used to develop it. This information can be used to increase the accuracy and detail of the estimate.

2.4.1.1 Input and outputs of estimation

A typical view of cost estimation approach is depicted in Figure 2-7

Estimation Inputs: The inputs of the estimation process are show on the left. The typical inputs are (McConnell, 2006)

- Project requirements
  - The Functional/ Technical requirements and standards by the customer.
  - The Non Functional requirements like hardware, procedures, manuals, work packages, etc.
- Project development process
  - Life cycle of the project. E.g. Safety project or Non Safety project.
  - System types.
- Project constraints
  - Deadlines
  - Budget availability
  - New technology
  - Expert resource availability

Estimation Process: In Figure 2-7 the center is chosen the representation of estimation model chosen and the tools required for the total process.

Estimation Output: On the right is chosen the estimation outputs which is normally estimate or a bid to the customer, preliminary plan and resource requirement.

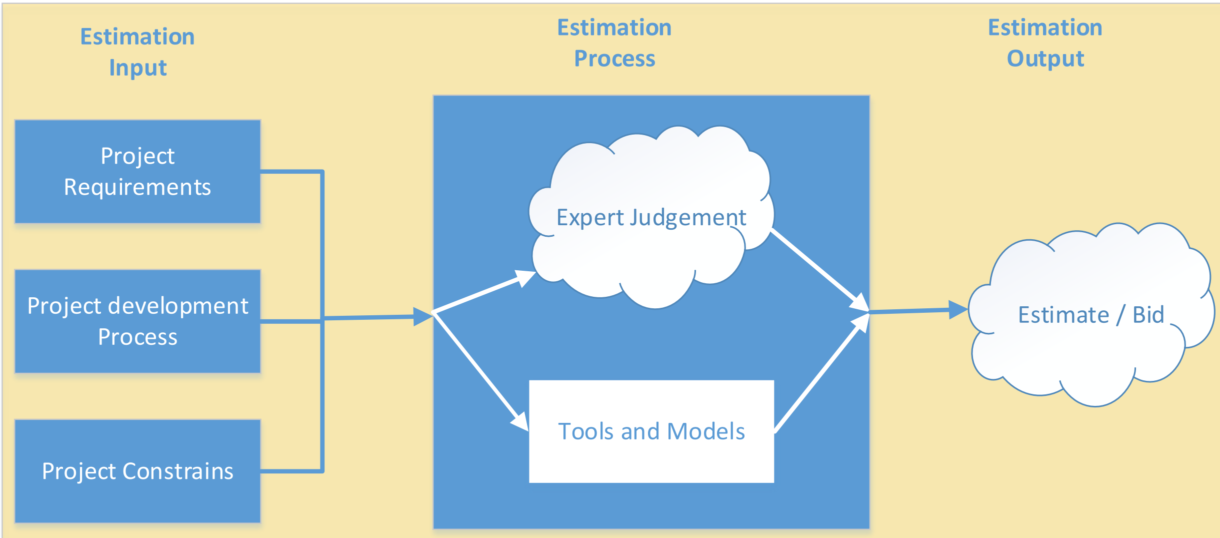

Figure 2-7 Perception of Estimate Process

2.4.1.2 Poor estimation practices

There is knowledge pool of articles in literature on project estimation. But in practice organizations have been facing issues with poor estimation practices illustrated in Figure 2-8

Estimation Inputs:

- Poorly defined or poorly documented requisition from customer. This type of estimation is input can be referred as 'wish list' which changes over time and causes scope creeps in the project. Some more reasons for poor requirements are (Boehm, 1981)
  - Using previous project data without considering the new project characteristics.
  - Customer often does not have resource that has full understanding of the supplier systems and technology.
  - Not considering the size units.
- Instead of what is required for the estimation and bid, going into too much details about project execution requirement. It can be caused by over enthusiasm from the technical teams and may lead to delays in the bidding processes.
- Sales team wants to take as many cost drivers as possible into account to lower estimation risks. This over optimism will eventually increase the estimated cost.

Estimation Model:

- The estimation is prepared by so called experts often varies between person to person. There is no scientific approach used by experts. Generally it is a guesstimate.
- Several tools used by the sales or estimation teams, which are not integrated often causes delays in the process.
- Total reliance on outside number without strong support evidence.
- No verification on the assumptions and too many variables for statistical analysis

- Several organizations entirely depends on expert judgement. There are no models used for estimation process.
- No project is same. But it is required to visit previous project estimations to be able to provide accurate estimates for future projects.

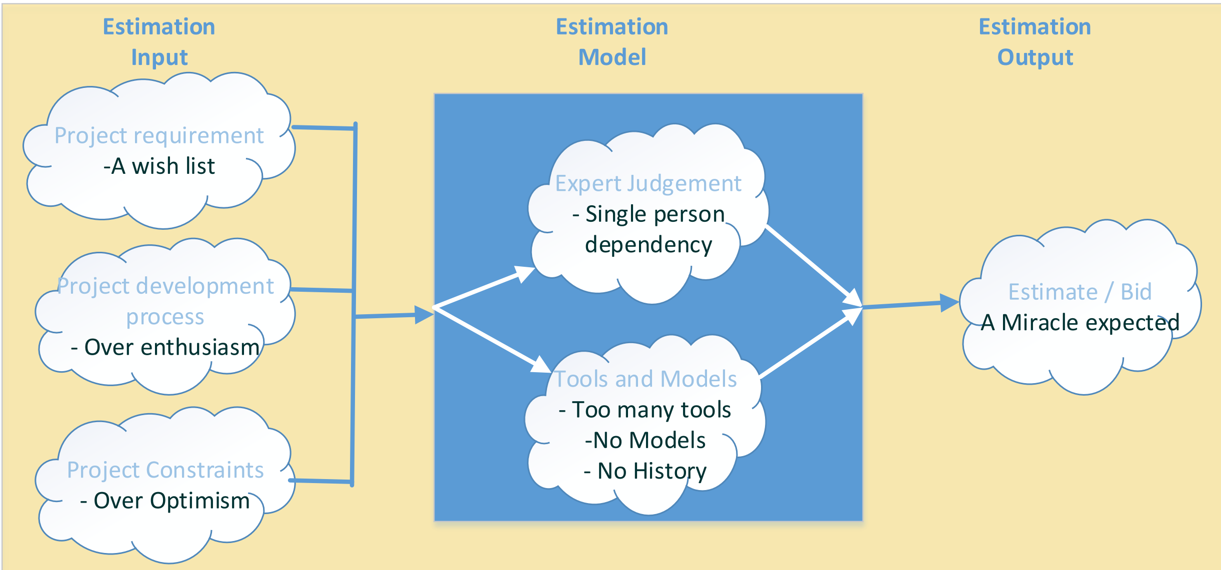

Figure 2-8 Poor Estimation Practices

<u>Estimation Output:</u>

- A single estimate, which is made up of the mandated project budget and schedule must be respected by the entire organization. This figure does not consider unplanned overtimes etc.
- Over optimistic attitude by sales team, that the development team outperforms previous historical performance and overcomes all constraints (Abran, 2015).
- Limited or no validation of the estimate after the end of the project

To summarize in this process, both customers and management expect that their staff and suppliers will commit to delivering the expected functionality on time and budget, and all this without having any benchmarking to the project, without considering uncertainties. The managers, customers and staff expect a miracle every time they start new projects.

2.4.2 Cone of Uncertainty

In project management, the Cone of Uncertainty describes the evolution of the amount of uncertainty during a project. Uncertainty not only decreases over time passing, but it also diminishes its impact by risk management, specifically by decision-making. (Ricardo & Vicente, 2015).

Ricardo and Vicente (2015) mentioned that, “at the beginning of any project, very little information is available about the product or work results, and so estimates are subject to large uncertainty. As more research and development is done, more information is learned about the project, and the uncertainty then tends to decrease, reaching 0% when all residual risk has been terminated or transferred. This usually happens by the end of the project i.e. by transferring the responsibilities to a separate maintenance group".

The Cone of Uncertainty is narrowed both by research and by decisions that remove the sources of variability from the project. These decisions are about scope, what is included and not included in the project. If these decisions change later in the project then the cone widens.

Research in the different industry on the Cone of Uncertainty stated that in the beginning of the project life cycle (i.e. before gathering of requirements, Time=0) estimates have in general an uncertainty of factor 4 times on the high side and 1/4 times on the low side (Boehm, 1981) as shown in Figure 2-9. This uncertainty tends to decrease over the course of a project, although that decrease is not guaranteed (McConnell, 2006). At the end of the project (i.e. Time= end of the project), the information on effort, duration and costs (i.e. dependent variables) is known relatively accurately (depends on the historical data collection process for effort recording).

One way to account for the Cone of Uncertainty in the project estimate is to first determine a 'most likely' single-point estimate and then calculate the high-low range using predefined multipliers (dependent on the level of uncertainty at that time). This can be done with formulas applied to spreadsheets, or by using a project management tool that allows the task owner to enter a low/high ranged estimate and will then create a schedule that will include this level of uncertainty.

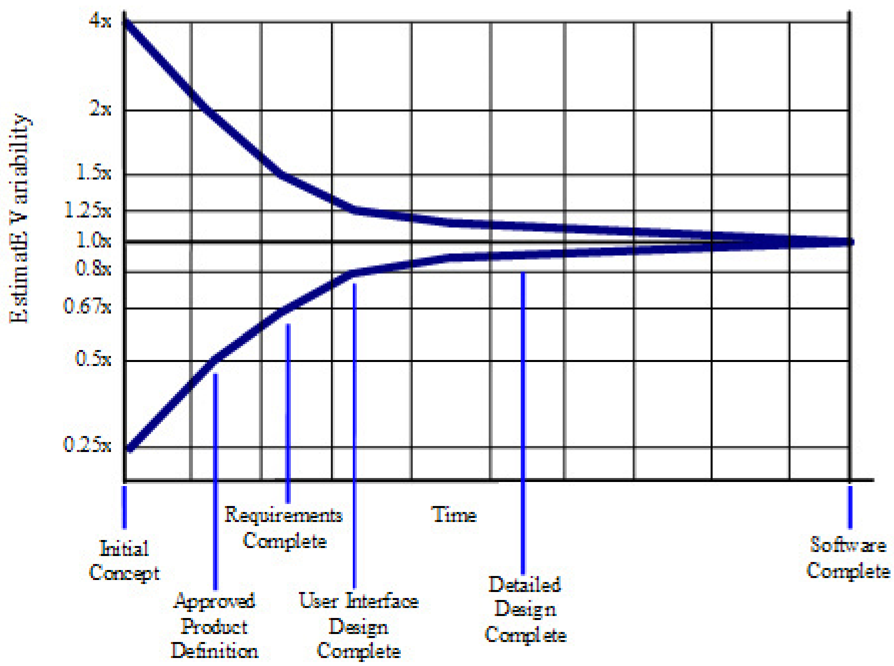

Figure 2-9 Cone of Uncertainty (Adapted from (Boehm, 1981))

The similar philosophy can be applied to sales and estimation process. The accuracy of the project estimates depends on the level of refinement of the requirements definition. The more refined the definition, the more accurate the estimate. The reason the estimate contains variability is that the projects itself contains variability. The only way to reduce the variability in the estimate is to reduce the variability in the project itself (McConnell, 2006).

2.4.3 Pricing Model

Any customer is ideally looking for a project at a fixed cost and to be on time and on budget, while expecting that all the quality targets will be met as well. Abran, (2015) said that in practice this does not happen often because there is an asymmetry of information between customer and suppliers.

According to (Construction Industry Institute, 1986), the choice and selection of the pricing model depends on the following factors.

- The accuracy, definition and extent of work to be executed.
- The criticality and technical complexity of the job.
- The risk appetite of the customer.
- The extent of customer 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.

Though PMBOK, (2008) has described 3 pricing models Fixed-price Contract, Cost -reimbursable contracts, Time and Material Contract models, there are only 2 generic models generally used.

Time and Material billing model (Reimbursable model)

The customer pays for the effort expended on their project by the project staff, at an agreed price per each member throughout the project life cycle. This means that a budget is allocated ahead of time by supplier and that supplier is not bound contractually to deliver within the budget, within the deadline, within the quality. The supplier is bound to best practices but not unknown budget figures. The customer takes care all the budget related risks. Most of the business risks are taken care of by customer (Abran, 2015). This model provides the customers a flexibility to redirect a supplier whenever the scope of work cannot be precisely defined at the start and needs to be altered, or when high risks may exist in the effort.

Fixed price Model

The supplier is legally bound to deliver all the project requirements within the specified budget, deadlines and quality levels. In these models the supplier is taking all the risks, and correspondingly should have been included within the contract, upfront within the agreed price, high contingencies to handle risks. Most of the business risks is taken care by customer (Abran, 2015). In this model the customer need to precisely specify the product or services being procured. Changes in scope may be accommodated, but generally with an increase in contract price.

2.4.4 Estimation models

The methods and techniques used to prepare a cost estimate typically vary based on the level of project definition available at the time the estimate is prepared (AACE, 2011) (AACE, 2016). Early in a project's lifecycle, there is a need to prepare conceptual cost estimates to support timely decision-making such as to make a "go or no-go" decision to continue development of a project proposal or to select between alternative designs.

"Researchers need to consistently compare estimation methods across many data sets in order to be able to define guidelines about what kind of models to use for a given environment." (Briand & Wieczorek, 2002).

Project managers and top management want early and accurate estimations on the effort needed to execute a project. A number of alternative estimation methods have been proposed by several researchers. But each method tends to have drawbacks and advantages, making them suitable in different environments. Among the variety of existing estimation methods, selecting the most appropriate method is important.

2.4.4.1 Expert judgement model

Expert Judgment – use of knowledge gained from experience. Expert judgment provides valuable information about the organizational environment and information from prior comparable projects. This estimation is easy to use, provided an expert is available on the project or organization. The expert needs to create an estimate based upon their understanding of the project requirements. The advantage of this technique is that it is quick and if the expert is knowledgeable, it is often the most accurate estimate for uncertain activities. The disadvantages are that availability of the experts, the expert often can provide no solid rationale for their estimate beyond certain bandwidth and dependency on a single person.

To give the adequate wide bandwidth for the estimate it is essential to compare the details that are required to standardize the estimation with respect to other expert, a standard technique known as Delphi technique (Allan, 1979) is launched. The steps for estimating the use of Delphi technique are shown in Figure 2-10:

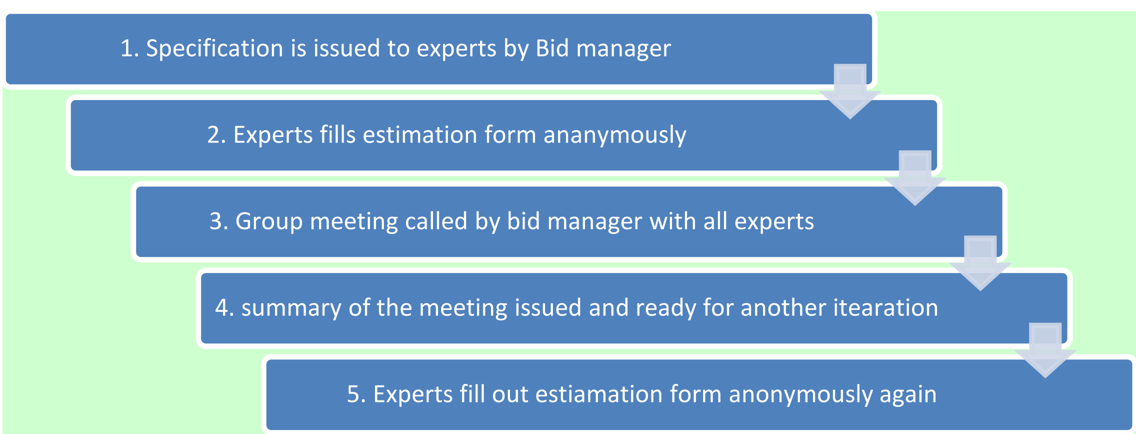

Figure 2-10 Delhi Technique used by Expert judgement estimation method

As shown in Figure 2-11, initially each experts might provide wider range of values for each activity, as the iterations goes on all the experts comes to an agreement and the range of values narrows down.

<u>Advantages:</u>

- The experts evaluates differences between past project experience and requirements of the proposed project.

- The experts can check the project impacts caused by new technologies, customers, resources involved in project and can also factor in exceptional personnel characteristics and Interactions.

Disadvantages:

- It is difficult to document the factors utilized by the experts or experts-group.
- This method could not be quantified. The expert judgment method mostly compliments the other cost estimating method such as algorithmic method (McConnell, 2006). Experts may be optimistic, pessimistic, and biased.
- Its time taking process and expensive process.

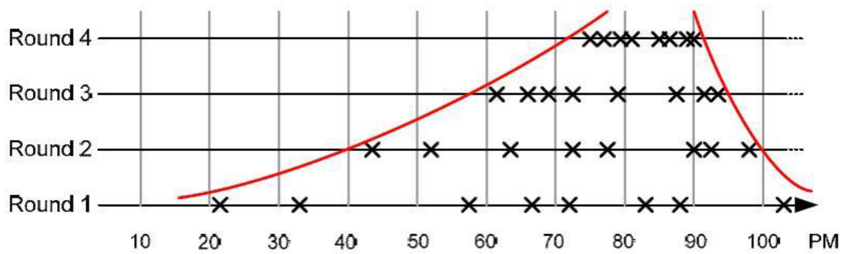

Figure 2-11 Iterations in Delphi technique

Reasons for the continuing cost overrun problems could be lack in estimation ability and the use of inefficient techniques when producing the estimates. As expert judgment estimation is still the pre dominate way of doing effort estimation, one also has to consider the human factor in deriving estimates (Jørgensen, 2004). Humans have a general overconfidence in own abilities, which also has its effect on software effort estimation. Overconfidence leads to an underestimation of effort needed to complete a task. It is also dangerous to view software estimation as a rational exercise. The estimation process is not completely rational, where the only objective is an accurate estimate. We have to recognize that goals such as pleasing managers influence the estimation process (Jørgensen, 2004). It is likely that the actual estimates are biased in order to fulfil other goals than reaching the most accurate estimate. From the estimation process to the humans involved, it is obvious that there is an improvement potential in the way effort estimation is done in the software development industry. A way in which to help fulfilling this potential is by, in line with suggested software process improvement frameworks, doing empirical research on different estimation factors and approaches, and to use collected data as a contribution in the effort to develop best practices for different software effort estimation settings.

2.4.4.2 Estimating by Analogy model

Analogous Estimation uses the metrics from a previous, similar project as the basis of estimation for the current project. Analogous estimating takes the actual effort and cost of previous, similar projects as a baseline and then adjusts for known differences (such as size, complexity, scope, duration, etc.). Analogy methods for estimation could make its utilization at the component-level or at system-level (Allan, 1979). This estimation often can be used together with Expert judgment estimation, since most of the times experts looks for previous project data.

The step for making use of estimation by analogy is as followed:

1. The proposed project is been characterized.

2. Making the selection of the most similar completed project whose characteristic had been store in an historical database.

To derive the estimation for a propose project by analogy from the most similar completed projects. In this method, function of similarity like Manhattan similarity (MS), Shepperd and Euclidean

Advantages:

- Estimating depends on the characteristic data of actual project.
- The knowledge and past experience of estimator's could be utilized.
- The difference among proposed project and completed one could identifies and estimated impacts.
- The risk and opportunities can be verified at the same time by comparing to the other project.

Disadvantages:

- There might be several variables effecting the project and estimation. The choice of variables must be restricted to information that is available at the point that the prediction required. Possibilities include the type of Green field/ Brown field, No of inputs, Customer, Hardware / Software etc.
- There might be a question about which project to compare with and how much confidence can we place in the analogies. Each project is different, so it might be difficult to find a similar project to compare with. Martin Sheppard etc. introduced the method of finding the analogies by measuring Euclidean distance in n-dimensional space where each dimension corresponds to a variable. Values are standardized so that each dimension contributes equal weight to the process of finding analogies. But practical implementation ids difficult.
- Sometimes the effort values from the analogous projects are not captured properly to use it for future estimate. If those values are still used it will end up as disaster during project execution.

2.4.4.3 Top-down and Bottom-up model

The main principle of these methods I, project is divided in the various low level component or mechanisms. The top-down approach is based on a simple calculation: divide total expenditure for a given area or policy by total units of activity (e.g. total hours spent) to derive a unit cost. The units of activity are specific to the services that are being costed, for example engineering, design. Typically this approach uses aggregate, budgetary data to estimate a unit cost. The bottom-up approach provides a greater level of granularity than the top-down method. It involves identifying all of the resources that are used to provide a service and assigning a value to each of those resources. These values are summed and linked to a unit of activity to derive a total unit cost – this provides a basis for assessment of which costs can be avoided as a result of reduced demand.

Advantages are:

- These methods requires minimum details of project. It is faster generally and simple for implementation.
- It focused on activities of system level such as Engineering, integration, documentation, Commissioning some of which might get ignores in other methods of estimation.

Dis-advantages are:

- These methods doesn't provide the details for justifying the estimate or decisions.
- It doesn't identify the difficulty of low level problem which could escalates cost and sometimes tend to over-look low level components.

2.4.4.4 Algorithmic model

Various cost estimation methods uses the algorithmic method which is classified into different models. For estimating the project cost each model uses the equation:

Efforts = f(x1, x2,...,xn)   Where the vector of the cost factor is (x1,x2,…,xn).

The equation is dependent on the historical research data and utilizes this input as design methodology, risk assessments, skill levels, number of functions to perform and other cost drivers such as system type, onshore /offshore. The algorithmic models have different kind of mathematic models such as Putnam model, COCOMO models, and models based on function points (Allan, 1979).

Advantages:

- It is easy to modify input data and also refine as well as customize formulas.
- Estimations can be generated repeatedly without delays.
- The previous experience can be utilized properly.
- This method can be used together with other estimation methods.

Disadvantages:

- Inaccurate cost driver and improper inputs results in inaccurate estimation.
- Some experience and factors cannot be easily quantified.
- It is unable to deal with exceptional conditions like exceptional teamwork, exceptional personnel in the projects and exceptional match between skill-levels and tasks.

2.4.4.5 Parametric effort estimation model

Parametric Estimation uses a statistical relationship between historical data and other variables (for example, No of Inputs/ Outputs in SAS projects) to calculate an estimate for activity parameters, such as scope, cost, budget, and duration. If this technique is used properly, it can produce high levels of accuracy.

NASA has defined it as "parametric estimating model is a mathematical representation of cost relationships that provide a logical and predictable correlation between the physical or functional characteristics of a project (plant, process system, etc.) and its resultant cost" (Nasa, 2015).

Parametric effort models can be a valuable resource in preparing early conceptual estimates. They are often used during both the concept screening and feasibility stages of a project. Parametric models can be surprisingly accurate for predicting the costs of even complex process systems. Parametric estimating models can be developed using basic skills in estimating, mathematics, statistics, and spreadsheet software. It is important to understand that the quality of results depends on the quality of input data, and great care should be taken during the data collection stage to gather appropriate and accurate project scope and cost data.

Researchers found out that following factors were the major contributors to variations in productivity for design projects (Boehm, 1981) (Hamdi & Vince, 2001):

- Product complexity
- Technical difficulty: severity of requirements, use of new technology
- Experience, skill, and attitude of team members
- Team structure: team size, methods of communication
- Use of design assisted tools
- Use of a formal process

Inclusion one or more of the above factors in a model depends on the characteristics of the historical projects in the data set. Unfortunately, there is no specific approach that helps to define the formula for the model that best fits historical data, however (Hamdi & Vince, 2001) have proposed the following form

$$\hat{E} = a\, PC^{b}\, SR^{c} \qquad \text{2-1}$$

$\hat{E}$ = design effort
PC = project complexity
SR = severity of requirements
a, b, c = constants.

Product complexity is estimated by the following metric (Hamdi & Vince, 2001),

$$PC = \sum_{j=1}^{l} F_j j \qquad \text{2-2}$$

F j = number of functions at level j
l = number of levels

The formula for product complexity is not derived. It was created when considering how to estimate product complexity (Hamdi & Vince, 2001) it is clear that number of functions does not work well as an estimate of complexity. The user have to try different formulas by functional analysis. The formula given in equation worked well in tests of individuals doing design work as well as large design projects in companies. Intuitively, the more functions in a design, the more complex is the design.

Severity of requirements is rated on a scale of 1 to 3, where

- 1: design requirements are not too difficult to meet
- 2: design requirements are difficult to meet
- 3: design requirements are extremely difficult to meet

The constants in equations vary from one development environment to another and can be determined by regression analysis applied to historical data. For example, Hamdi & Vince (2001), derived the following parametric model formula for the project they were working.

$$\hat{E} = 70.6\ PC^{1.15}\ SR^{.87} \tag{2-3}$$

Projects typically involve many dynamic aspects, yet they're often constrained by finite conditions. These contradictory forces make it very difficult to determine with pinpoint accuracy the time and effort required. By using a set of proactive estimating techniques to scope, plan, and constrain project conditions can dramatically improve estimating practices. Further can reduce, mitigate risks, and increase the project success rate.

Advantages

- Efficient: Parametric estimation models require less engineering and level of project definition to support the estimate. The estimate can be prepared in much less time than required by more other techniques.
- Objective: Parametric models require quantitative inputs that are linked to algorithms providing quantitative outputs. All costs are traceable.
- Consistent: If two estimators input the same values for parameters, they will get the same resulting cost. Parametric models also provide a consistent estimate format and estimate documentation.
- Flexible: Parametric models provide costs for a range of input values, generalizing to derive costs for projects of a different size or nature than the history available. The models can be easily adjusted to provide cost sensitivity analysis for proposed design changes.
- Defensible: The models highlight the design parameters used, and can provide key statistical relationships and metrics for comparison with other projects.

Disadvantages:

- The development costs for the model may not justify the purpose of the model.
- The accuracy level of the model depends on the variables and relation between them.
- The Complexity might be high.

The development of a parametric estimating model can appear to be a difficult task; however the use of modern technology (including spreadsheet programs) can make the process tolerable, and much easier than it would have been years ago (Dysert, 1999). The process of developing a parametric model should generally involve historical data collection and analysis techniques explained in Section 2.3 and 3.3.

2.4.5 Regression analysis

Regression Analysis is an analytic technique where a series of input variables are examined in relation to their corresponding output results in order to develop a mathematical or statistical relationship.

Regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning. Regression analysis is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. In restricted circumstances, regression analysis can be used to infer causal relationships between the independent and dependent variables (Armstrong, 2012).

Many techniques for carrying out regression analysis have been developed. Familiar methods such as linear regression and ordinary least squares regression are parametric, in that the regression function is defined in terms of a finite number of unknown parameters that are estimated from the data. Nonparametric regression refers to techniques that allow the regression function to lie in a specified set of functions, which may be infinite-dimensional.

Regression models involve the following variables:

- The unknown parameters, denoted as β, which may represent a scalar or a vector.
- The independent variables, X.
- The dependent variable, Y.

In various fields of application, different terminologies are used in place of dependent and independent variables.

A regression model relates Y to a function of X and β. $Y = F(X, \beta)$

Linear Regression

In linear regression, the model specification is that the dependent variable, Y_i is a linear combination of the parameters (but need not be linear in the independent variables). For example, in simple linear regression for modeling data 'n' points there is one independent variable X_i, and two parameters $\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_1}$. An example of Linear Regression Function

$$Y_i = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} X_i + \epsilon_i \qquad 2\text{-}4$$

Where i = 1,…., n.

In Linear the functions might be straight line, Parabolic

Non Linear Regression

Nonlinear regression is a form of regression analysis in which observational data are modeled by a function which is a nonlinear combination of the model parameters and depends on one or more independent variables. The data consist of error-free independent variables X, and their associated observed dependent variables (response variables), Y. Each Y is modeled as a random variable with a mean given by a nonlinear function F(X,β). Systematic error may be present but its treatment is outside the scope of regression analysis. An example of Nonlinear Regression Function

$$Y = F(X, \beta) = \frac{\beta_1 X}{\beta_2 + X} \qquad 2\text{-}5$$

This function is nonlinear because it cannot be expressed as a linear combination of the two β's. Other examples of nonlinear functions include exponential functions, logarithmic functions, trigonometric functions, power functions, Gaussian function, and Lorenz curves.

2.4.6 Constraints in Estimation model

Several studies have surveyed the accuracy of effort and schedule estimation. The results of these survey showed that 59%-76% projects were completed over estimated effort and 35%-80% were over schedule. There are several constraints in estimation models.

Improving models is hard to achieve in the industry and it is done very less frequently in many organizations. It is due to number of particular challenges (Jørgensen, 2004).

- There is a rarely single estimated budget. Over the course of the project, there are several re- estimate or several Variation order requests (VOR) that are created.
- The information used as input to the estimation process is not documented properly. The quality or completeness is neither recorded nor analyzed.
- Assumptions are not documented properly.

Researchers discussed many possible reasons for the low adoption rate of model-based methods, e.g. many of these models are not very accurate , many organizations do not collect sufficient data to allow the construction of such models , organizations feel uncomfortable to use models they do not fully understand (Jørgensen, 2004), etc. Some more constrains for estimation models are explained in Table 2-2.

Constrains	Causes
Inaccurate Nature of requirements	• The completeness of the requirements • Ambiguities and omissions in the requirements due to lack of technical knowledge • Changes or instability of requirements during the project life cycle.
Uncertainty factors which could impact the project	• The experience of the project manager • The experience of the project team • The technical complexity
Risks	• Competent resource not available • Loss of key people

Table 2-2 Constraints in Estimation models

Estimate accuracy in EPC organization in process industries is driven by systemic risks such as: (AACE, 2016)

- Level of non-familiar technology in the project.
- Complexity of the project.
- Quality of reference cost estimating data.
- Quality of assumptions used in preparing the estimate.
- Experience and skill level of the estimator.
- Estimating techniques employed.
- Time and level of effort budgeted to prepare the estimate.
- Unique/remote nature of project locations and the lack of reference data for these locations.
- The accuracy of the composition of the input and output process streams.

These constraints needs to be addressed through an estimation process defined in Section 3.1.

2.5 Projects

PMBOK, (2008) defines “A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. The end is reached when the project’s objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists”. The objectives might not met because of the following reasons.

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. Project management is accomplished through the appropriate application and integration of the 47 logically grouped project management processes, which are categorized into five Process Groups. These five Process Groups are: Initiating, Planning, Executing, Monitoring and Controlling, and Closing.

Organizational project management (OPM). OPM is a strategy execution framework utilizing project, program, and portfolio management as well as organizational enabling practices to consistently and predictably deliver organizational strategy producing better performance, better results, and a sustainable competitive advantage.

A project management office (PMO) is a management structure that standardizes the project-related governance processes and facilitates the sharing of resources, methodologies, tools, and techniques. The responsibilities of a PMO can range from providing project management support functions to actually being responsible for the direct management of one or more projects.

All the above definitions indicate that a project is characterized by its temporary character, in which a (unique) scope of work is undertaken, within certain constraints and for a particular reason.

The PMO integrates data and information from corporate strategic projects and evaluates how higher level strategic objectives are being fulfilled. The PMO is the natural liaison between the organization’s portfolios, programs, projects, and the corporate measurement systems (e.g. balanced scorecard). The specific form, function, and structure of a PMO are dependent upon the needs of the organization that it supports (Fusco, 1997).

A PMO may have the authority to act as an integral stakeholder and a key decision maker throughout the life of each project, to make recommendations, or to terminate projects or take other actions, as required, to remain aligned with the business objectives. In addition, the PMO may be involved in the selection, management, and deployment of shared or dedicated project resources.

These project as an on-going process, which must be consistently measured and adjusted according to the real performance (Tuner & Muller, 2003). They consider that any project has unclear constraints and limitations that are hardly mapped in the planning phase (Perminova, 2011). Therefore, the (new) risk/uncertainty management has developed/adapted strategies oriented to identify and mitigate these uncertain events.

The project management is a matter of robust decisions, rather than optimal decisions. The reason is that in order to have the project rolling, decisions have to be made without all the required information (Shenhar & Dvir, 2007). In addition, the project involves multiple stakeholder with different interests. Therefore, the coordination of the processes and parties must be handled.

Shenhar & Dvir, (2007) suggest that different parts of the project management problem could be tackled with developments in the different theoretical bases, hence emphasizing the multidisciplinary character of project management.

Table 2-3 shows the Project management characters in terms of issues.

Project management problem	Theoretical perspective
Scheduling and resource allocation	Operations research , network theory
Time overruns, escalating resources	Theory of constraints - critical chain
Uncertainty and risk management	Simultaneous management, knowledge and time perspectives
Adapting project management to project differences	Contingency theory – a typological theory of project management, distinction between hard and soft aspects of projects
Project leadership	Transformational leadership
Project strategy	Strategic management

Table 2-3 Character of Project Management

Though temporary in nature, projects can help achieve the organizational goals when they are aligned with the organization's strategy. Organizations sometimes change their operations, products, or systems by creating strategic business initiatives that are developed and implemented through projects. Projects require project management activities and skill sets, while operations require business process management, operations management activities, and skill sets.

Projects can intersect with operations at various points during the product life cycle, such as:

- At each closeout phase;
- When developing a new product, upgrading a product, or expanding outputs;
- While improving operations or the product development process; or
- Until the end of the product life cycle.

Examples include: production operations, manufacturing operations, accounting operations, software support, and maintenance. At each point, deliverables and knowledge are transferred between the project and operations for implementation of the delivered work.

2.5.1 Project management alignment with Organizational strategy

Organizations use governance to establish strategic direction and performance parameters. The strategic direction provides the purpose, expectations, goals, and actions necessary to guide business pursuit and is aligned with business objectives. Project management activities should be aligned with top-level business direction, and if there is a change, then project objectives need to be realigned. In a project environment, changes to project objectives affect project efficiency and success (Gereth, 2013). When the business alignment for a project is constant, the chance for project success greatly increases because the project remains aligned with the strategic direction of the organization. Should something change, projects should change accordingly.

Organizational strategy should provide guidance and direction to project management- especially when one considers that projects exist to support organizational strategies. Often it is the project sponsor or the portfolio or program manager who identifies alignment or potential conflicts between organizational strategies and project goals and then communicates these to the project manager (Gereth, 2013). If the goals of a project are in conflict with an established organizational strategy, it is incumbent upon the project manager to document and identify such conflicts as early as possible in the project. At times, the development of an organizational strategy could be the goal of a project rather than a guiding principle. In such a case, it is important for the project to specifically define what constitutes an appropriate organizational strategy that will sustain the organization.

Improvements in an organization are an ongoing process and the need to decrease time and costs in projects is usually always present. A general problem in PM is to meet time and cost goals and much of the PM literature focus on how to achieve these goals. Taking lessons from other areas such as QM on how to structure and continuously improve processes could support the field of PM to evolve. As indicated, the concepts can be used to help put focus on different perspectives of PM in the project-based organization and provide structure for improvements. Applying the concepts on PM might also help develop new performance indicators in order to support and steer improvement efforts (Sisney, 2012).

Working with improving PM-efficiency could result in increased output from invested resources, and improving PM-effectiveness would ensure that all output meet customer requirements (Sisney, 2012). The company’s focus on carrying out one project at a time, and as long as time, cost and scope requirements were met, little effort were spent on learning from and improving PM-processes (Sisney, 2012).

Project success can be viewed narrowly as achievement of intended outcomes in terms of specification, time and budget. Whilst this was widely accepted as appropriate in early writings on project management the project context has shifted and it is now recognized that a broader set of outcome measures is now generally needed (Atkinson, 1999; Pinto and Slevin, 1988; Wateridge, 1998). The performance indicators like Earned Value Analysis would put focus on other aspects reflected in the concepts, and increase diversity among available performance indicators. These aspects include internal and external as well as short and long-term objectives. With efficiency and effectiveness in project management the project-based organization can strive to ensure that what is carried out is performed in the best possible way, and that the outcome is the best suitable outcome for the customer.

Within knowledge-based enterprises projects are also being considered as an arena for learning; the uniqueness of projects makes rich in opportunities for personal and organizational learning (Ays, 1996). We might also include criteria such as knowledge creation and dissemination, which today many project owners include as factors that determine if the project is successful or not (Fusco, 1997).

2.5.2 Project Complexity

Projects are unique only to a certain extent. But number of risks, uncertainties that occurs are similar in several projects (Perminova, 2011). Webster's Encyclopedic Dictionary, 2001 defines that project complexity is characterized by a complicated arrangement of many interconnected parts, units, etc., and that the situation is complicated or difficult, to be hard to understand or deal with.

Some of the factors of project complexity mentioned by (Perminova, 2011)

- Details – number of variables and interfaces
- Ambiguity – lack of awareness of events and causality
- Uncertainty – inability to pre-evaluate actions
- Unpredictability – the inability to know what will happen
- Dynamics – rapid rate of change
- Social structure – numbers and types of interactions
- Interrelationships – many interdependencies and interconnections exist
- Culture – Global organizations

Generally project that consists of many interdependent variables should be treated as complex. The factors that are defined above directly effects the organizational performance (Perminova, 2011). Most of the literature concludes that failure to understand the complexity of the project and inability to recognize uncertainty often leads to project failure. When the same thing happening in several projects, it leads to organizational failure.

2.5.2.1 Project Complexity Model

The following Project Complexity Model attempts to capture dimensions of project complexity, the characteristics that are making a project unpredictable and dynamic. The model discusses the project management tools, methods and approaches that should be considered by the sales, project management team to manage the complexities.

The Project Complexity Model presented here provides a framework to diagnose the elements of complexity that exist on a particular project so that the sales and project management team can make the appropriate complexity management decisions (Katheleen, 2008). There are a number of dimensions of project complexity that are captured in the model, including: Project time and value, team size and composition, project urgency, schedule, cost and scope flexibility, clarity of the problem and solution, stability of requirements, strategic importance, stakeholder influence, level of organizational and commercial change, external constraints and dependencies, political sensitivity, and unproven technology.

To use the model to diagnose the complexity of a particular project

- From the Table 2-4 measure the each complexity dimension factor.
- Select and note the appropriate complexity dimension factor. Note that all conditions described within a complexity dimension factor shall be used;
- Based on the values from previous step and Table 2-4 Project Complexity model formula prepare a spider diagram as shown in the Figure 2-12 project Complexity mode

	Project Profile			
Complexity Dimensions	**Independent Project**	**Moderately Complex Project**	**Highly Complex Project**	**Highly Complex Program "Megaproject"**
Size/Time/Cost	**Size:** 3–4 team members **Time:** < 3 months **Cost:** < $250K	**Size:** 5–10 team members **Time:** 3–6 months **Cost:** $250–$1M	**Size:** > 10 team members **Time:** 6 – 12 months **Cost:** > $1M	**Size:** Multiple diverse teams **Time:** Multi-year **Cost:** Multiple Millions
Team Composition and Past Performance	**PM**: competent, experienced **Team**: internal; worked together in past **Methodology**: defined, proven	**PM**: competent, inexperienced **Team**: internal and external, worked together in past **Methodology**: defined, unproven **Contracts**: straightforward **Contractor Past Performance**: good	**PM**: competent; poor/no experience with complex projects **Team**: internal and external, have not worked together in past **Methodology**: somewhat defined, diverse **Contracts**: complex **Contractor Past Performance**: unknown	**PM**: competent, poor/no experience with megaprojects **Team**: complex structure of varying competencies and performance records (e.g., contractor, virtual, culturally diverse, outsourced teams) **Methodology**: undefined, diverse **Contracts**: highly complex **Contractor Past Performance**: poor
Urgency and Flexibility of Cost, Time, and Scope	**Scope**: minimized **Milestones**: small **Schedule/Budget**: flexible	**Scope**: achievable **Milestones**: achievable **Schedule/Budget**: minor variations	**Scope**: over-ambitious **Milestones**: over-ambitious, firm **Schedule/Budget**: inflexible	**Scope**: aggressive **Milestones**: aggressive, urgent **Schedule/Budget**: aggressive
Clarity of Problem, Opportunity, Solution	**Objectives:** defined and clear **Opportunity/Solution:** easily understood	**Objectives:** defined**,** unclear **Opportunity/Solution:** partially understood	**Objectives:** defined, ambiguous **Opportunity/Solution:** ambiguous	**Objectives:** undefined**,** uncertain **Opportunity/Solution:** undefined, groundbreaking, unprecedented
Requirements Volatility and Risk	**Customer Support:** strong **Requirements:** understood, straightforward, stable **Functionality**: straightforward	**Customer Support:** adequate **Requirements:** understood, unstable **Functionality:** moderately complex	**Customer Support:** unknown **Requirements**: poorly understood, volatile **Functionality:** highly complex	**Customer Support:** inadequate **Requirements**: uncertain, evolving **Functionality:** many complex "functions of functions"
Strategic Importance, Political Implications, Stakeholders	**Executive Support:** strong **Political Implications:** none **Communications:** straightforward **Stakeholder Management:** straightforward	**Executive Support:** adequate **Political Implications:** minor **Communications:** challenging **Stakeholder Management:** 2–3 stakeholder groups	**Executive Support:** inadequate **Political Implications:** major, impacts core mission **Communications:** complex **Stakeholder Management:** multiple stakeholder groups with conflicting expectations; visible at high levels of the organization	**Executive Support:** unknown **Political Implications:** impacts core mission of multiple programs, organizations, states, countries; success critical for competitive or physical survival **Communications:** arduous **Stakeholder Management:** multiple organizations, states, countries, regulatory groups; visible at high internal and external levels
Level of Change	**Organizational Change:** impacts a single business unit, one familiar business process, and one IT system **Commercial Change:** no changes to existing commercial practices	**Organizational Change:** impacts 2–3 familiar business units, processes, and IT systems **Commercial Change:** enhancements to existing commercial practices	**Organizational Change:** impacts the enterprise, spans functional groups or agencies; shifts or transforms many business processes and IT systems **Commercial Change:** new commercial and cultural practices	**Organizational Change**: impacts multiple organizations, states, countries; transformative new venture **Commercial Change:** ground-breaking commercial and cultural practices
Risks, Dependencies, and External Constraints	**Risk Level:** low **External Constraints:** no external influences **Integration:** no integration issues **Potential Damages:** no punitive exposure	**Risk Level:** moderate **External Constraints:** some external factors **Integration:** challenging integration effort **Potential Damages:** acceptable exposure	**Risk Level:** high **External Constraints:** key objectives depend on external factors **Integration:** significant integration required **Potential Damages:** significant exposure	**Risk Level:** very high **External Constraints:** project success depends largely on multiple external organizations, states, countries, regulators **Integration:** unprecedented integration effort **Potential Damages:** unacceptable exposure

Level of IT Complexity	**Technology:** technology is proven and well-understood **IT Complexity:** application development and legacy integration easily understood	**Technology:** technology is proven but new to the organization **IT Complexity:** application development and legacy integration largely understood	**Technology:** technology is likely to be immature, unproven, complex, and provided by outside vendors **IT Complexity:** application development and legacy integration poorly understood	**Technology:** technology requires groundbreaking innovation and unprecedented engineering accomplishments **IT Complexity:** multiple "systems of systems" to be developed and integrated

Table 2-4 Project Complexity Dimensions (Adapted from Kathleen B. Hass, 2008)

Highly Complex Program "Megaproject"	Highly Complex Project	Moderately Complex	Independent
Size: Multiple diverse teams, **Time:** Multi-year, **Cost:** Multiple Millions Or 2 or more in the **Highly Complex Program/Megaproject** column	**Organizational Change:** impacts the enterprise, spans functional groups or agencies, shifts or transforms many business processes and IT systems *Or* 3 or more categories in the **Highly Complex Project** column And No more than 1 category in the **Highly Complex Program/Megaproject** column	3 or more categories in the **Moderately Complex Project** column *Or* No more than 2 categories in the **Highly Complex Project** column and	No more than 2 categories in the **Moderately Complex Project** column *And* No categories in the **Highly Complex Project** or the **Highly Complex Program/Megaproject** column

Table 2-5 Project Complexity model formula (Adapted from Kathleen B. Hass, 2008)

2.5.2.2 Visualizing Project Complexity

In order to communicate the nature of the complexities on your project, it is helpful to create a visual depicting the overall project complexity by developing a "spider chart" similar to the one illustrated in Figure 2-12 Project Complexity mode.

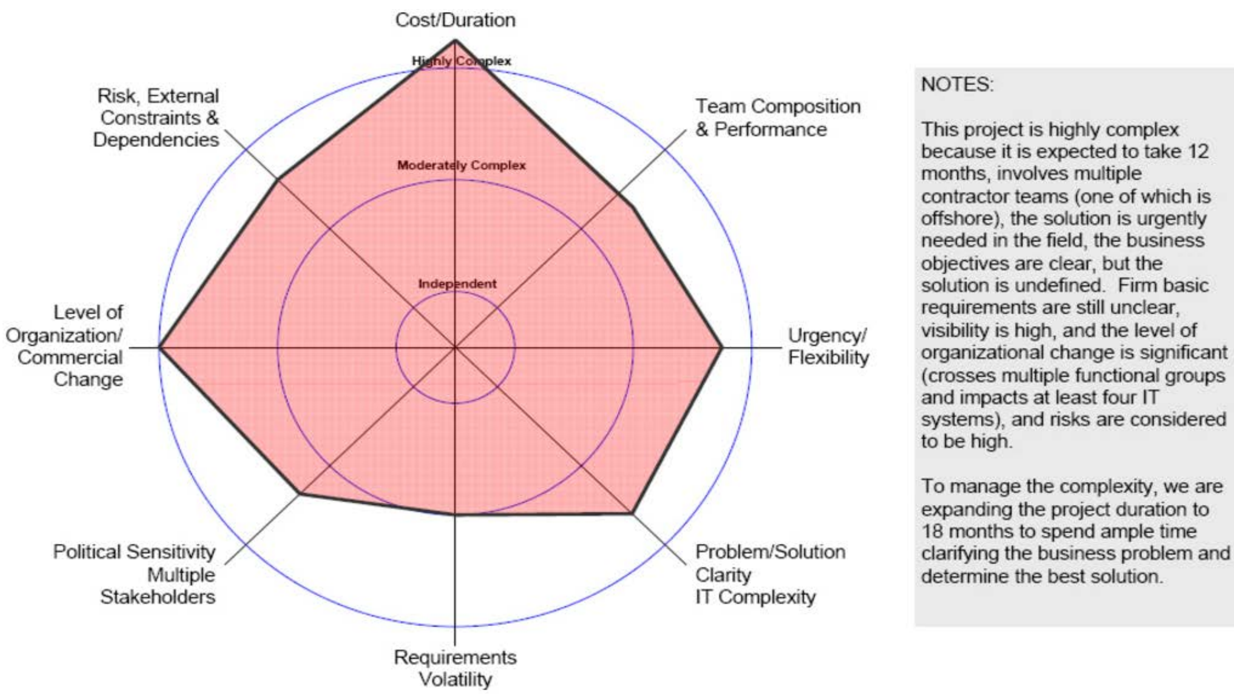

Figure 2-12 Project Complexity mode (Adapted from Kathleen B. Hass, 2008)

The Project Complexity Model shall be used during all phases of project life cycle. During the Sale/bidding time the bid team and project management team shall analyze and apply complexity thinking to the major decisions that are applicable for project. During the project execution time the project team and project manager shall analyze and apply complexity thinking. Organizations shall apply project complexity thinking approach when:

- Preparing the sales/tendering proposal for a new project
- Initiating and planning a new project
- Initiating and planning a new major phase of a project
- Recovering from uncertainties in project

When managing complex projects, the emphasis shall be on approaches that will add value to the project by utilizing the project team ability to adapt to learn and change in the environment and fine tune the project methods accordingly.

2.5.2.3 Applying complexity thinking

Applying complexity thinking to projects involves selecting appropriate methods and techniques, assigning project leadership, project cycles based on the project profile and the complexity dimensions. There are four steps in the process listed below.

- Step 1: Assign project leaders based on the project profile: Project sometimes fail because of inappropriate match of project leadership to the level of project complexity. The project manager, engineering manager, lead engineer are critical project leadership positions. Once the project complexity has been understood organization need to assign correct resources.
- Step 2: Select the project cycle based on the project profile: Based on the project profile diagnosed using the Project Complexity Model, the project team shall determines the appropriate project cycle to use. All projects have a cycle, a sequence of stages through which the project passes. Each stage defined with inputs and output that guides development, engineering and/or procurement of hardware equipment. As projects have become more complex, project cycles have evolved to address the various levels of complexity.
- Step 3: Select appropriate management techniques based on complexity dimensions: Projects sometimes fail because of misapplication of good management methods and techniques. The application of complexity thinking shall determine the appropriate techniques, tools, processes to be used based on the complexity dimensions present. Successful managers of complex projects become situational project managers by adapting their leadership style and the project management, tools, and processes to deal with the complexity dimensions that exist.
- Step 4: Design and build complex, adaptive business solutions: To design, build and maintain complex adaptive business solutions, which are almost always comprised of highly complex systems, Organizations shall understand and account for the business strategies as they evolve, as well as the system interrelationships and interdependencies. In addition, organizations be able to build and support nested systems within systems, complex business rules, and intricate feedback loops.

2.5.3 Work Breakdown Structure

PMBOK (2008) defined "WBS is a hierarchical decomposition of the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables". The WBS organizes and defines the total scope of the project, and represents the work specified in the current approved project scope statement. The planned work is contained within the lowest level of WBS components, which are called work packages. A work package can be used to group the activities where work is scheduled and estimated, monitored, and controlled.

2.5.3.1 Creating WBS

PMBOK (2008) described creating WBS is the process of subdividing project deliverables and project work into smaller, more manageable components. The key benefit of this process is that it provides a structured vision of what has to be delivered. The inputs, tools and techniques, and outputs of this process are depicted in Figure 2-13 and in Figure 2-14. The processes used to manage project scope, as well as the supporting tools and techniques, can vary by project. The scope baseline for the project is the approved version of the project scope statement, work breakdown structure (WBS), and its associated WBS dictionary.

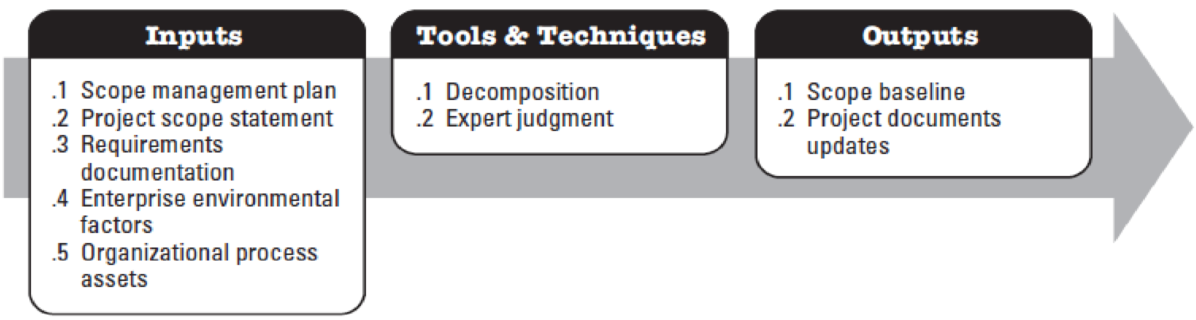

Figure 2-13 Work Breakdown structure inputs, outputs and tools (Adopted from PMBOK, 2008)

In creating WBS, One of the important step is Decomposition. According to Shenhar & Dvir, (2007), "Decomposition is a technique used for dividing and subdividing the project scope and project deliverables into smaller, more manageable parts. The work package is the work defined at the lowest level of the WBS for which cost and duration can be estimated and managed". The level of decomposition is often guided by the degree of control needed to effectively manage the project. The level of detail for work packages will vary with the size and complexity of the project. Decomposition of the total project work into work packages generally involves the following activities:

- Identifying and analyzing the deliverables and related work.
- Structuring and organizing the WBS.
- Decomposing the upper WBS levels into lower-level detailed components.
- Developing and assigning identification codes to the WBS component.
- Verifying that the degree of decomposition of the deliverables is appropriate.

The outputs of WBS process are

- Project scope statement: The project scope statement includes the description of the project scope, major deliverables, assumptions, and constraints.

- WBS: The WBS is a hierarchical decomposition of the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables.
- WBS dictionary: The WBS dictionary is a document that provides detailed deliverable, activity, and scheduling information about each component in the WBS.

Each descending level of the WBS represents an increasingly detailed definition of the project work. The WBS is finalized by assigning each work package to a control account and establishing a unique identifier for that work package from a code of accounts. These identifiers provide a structure for hierarchical summation of costs, schedule, and resource information. A control account is a management control point where scope, budget, actual cost, and schedule are integrated and compared to the earned value for project performance measurement. Control accounts are placed at selected management points in the WBS (PMBOK, 2008).

2.5.3.2 100% Rule

An important design principle for work breakdown structures is called the 100% rule (Gregory T, 2001). The 100% rule states that the WBS includes 100% of the work defined by the project scope and captures all deliverables – internal, external and interim – in terms of the work to be completed, including project management. The 100% rule is one of the most important principles guiding the development, decomposition and evaluation of the WBS. It is important to remember that the 100% rule also applies to the activity level. The work represented by the activities in each work package must add up to 100% of the work necessary to complete the work package.

A WBS structure may be created through various approaches. The WBS structure can be represented in a number of forms, such as:

- Using phases of the project life cycle as the second level of decomposition, with the product and project deliverables inserted at the third level.
- Using major deliverables as the second level of decomposition.
- Incorporating subcomponents which may be developed by organizations outside the project team, such as contracted work. The seller then develops the supporting contract WBS as part of the contracted work.

2.5.3.3 WBS Advantages

- <u>Boosts productivity:</u> The structure of work breakdown boosts productivity in the organization. It facilitates the identification of skills which are needed to finish assignments on time. By having the right set of people, the right number of them on the job and at the right time makes project productive.
- <u>Boosts transparency and accountability:</u> The structure of work breakdown will provide for a much level of details which will make it easy for those who are managing the projects. It will also let them understand their team members and hold them responsible for all tasks that have been completed. By having a proper and well defined breakdown structure, the team will enjoy a much greater level of transparency.
- <u>Identifies risk in a better way:</u> One of the best work breakdown structure benefits is that it identifies all risks and threats that are ahead of you and reduces the chances of them.

- Boosts progress in monitoring: The breakdown of work structure may also be used very easily to identify and quickly see the deliverables that are affected due to any delays in the project or because of certain work packages or maybe sub deliverables. The faster you will get the source of such delays, you will be able to take good action much faster and save your project from getting ruined.

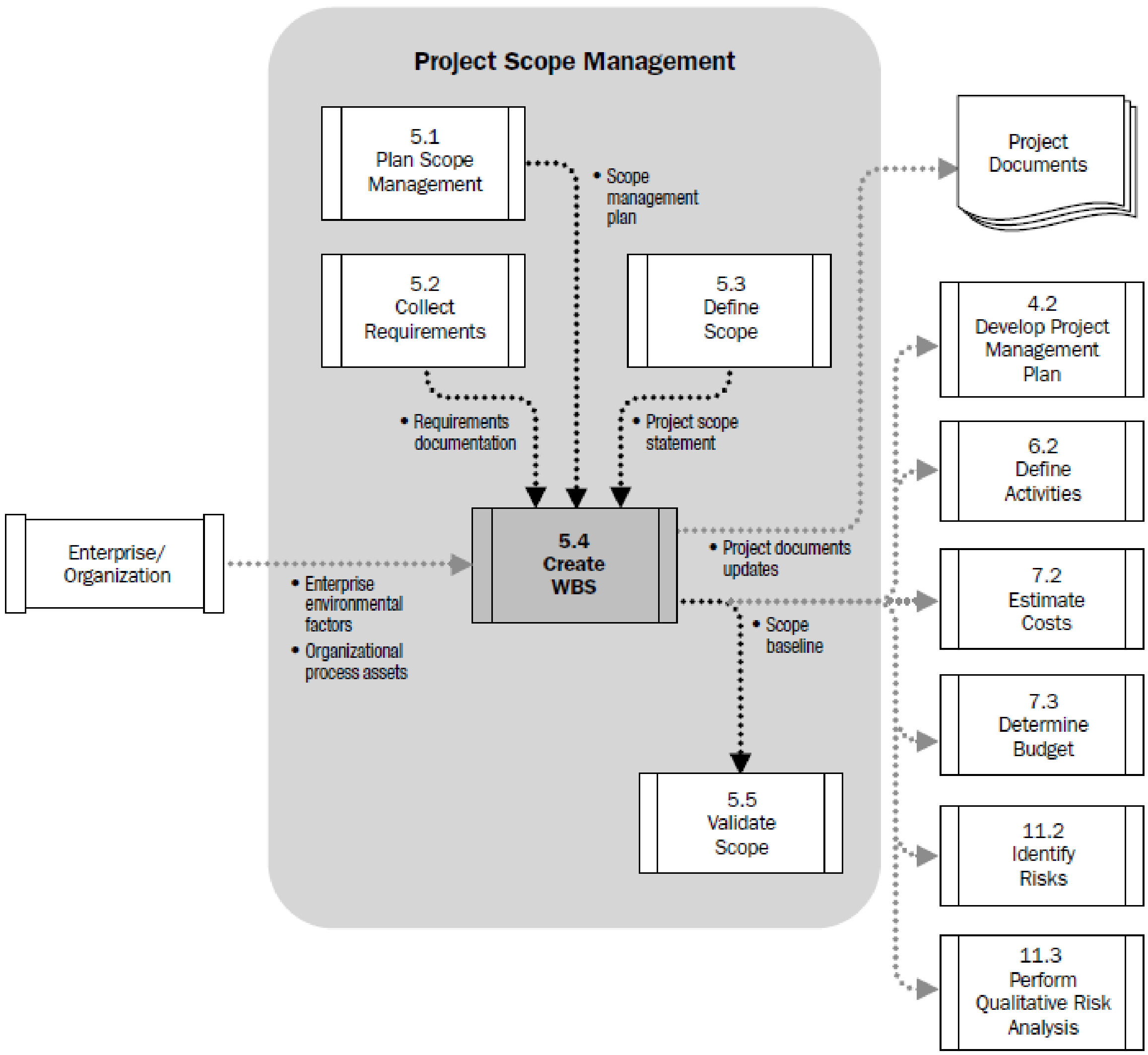

Figure 2-14 Creating WBS process, requirements, Inputs and Outputs (Adopted from PMBOK, 2008)

2.5.3.4 *WBS Disadvantages*

- The problem of requirements: Some of the deliverables and requirements cannot be converted into activities.
- Having plenty of activities: The decomposition activity level shall be stopped to a certain level. When the decomposition is too detailed and the no of hours of each activity is very less, it is hard to keep track of each and every activity, which makes lot of administration burden. Having lot of small activities makes the managers to keep a track of all of them which is quite a mess and ends up giving very poor results.

- Having more than 100% of WBS: A very important design principle of WBS is applying 100% percent rule which will state what it includes and its project scope at the same time. If the activities are not estimated properly (more or less hours for an activity), even though the project is performing well, those activities can catch unnecessary attention with management and customer. This could cause scope creeps.
- Can't get you correct details: It is definitely hard to find the best and most accurate level of details when it comes to WBS. If the requirements are not understand properly, it could lead to creation of useless and vague activities under which project has to be executed.
- Becomes outdated quite fast: Even the WBS method can dictate the project and schedule the whole thing, it becomes outdated after a point. This is probably because the schedule of the project will change the execution of such projects but the WBS shall always be the same.

2.5.4 Earned Value Analysis

Earned value management (EVM) is a methodology that combines scope, schedule, and resource measurements to assess project performance and progress. It is a commonly used method of performance measurement for projects. It integrates the scope baseline with the cost baseline, along with the schedule baseline, to form the performance baseline, which helps the project management team assess and measure project performance and progress. It is a project management technique that requires the formation of an integrated baseline against which performance can be measured for the duration of the project. EVM develops and monitors three key dimensions for each work package and control account: Planned Value (PV), Earned Value (EV), Actual Cost (AC) (PMBOK, 2008)

- Planned value (PV) is the authorized budget assigned to scheduled work.
- Earned value (EV) is a measure of work performed expressed in terms of the budget authorized for that work.
- Actual cost (AC) is the realized cost incurred for the work performed on an activity during a specific time period.

Earned value analysis and other methods of project variance and trend analysis may be used for monitoring overall project performance. The Earned value analysis formulas are shown in Table 2-6. Outcomes from these analyses may forecast potential deviation of the project at completion from cost and schedule targets. Deviation from the baseline plan may indicate the potential impact of threats or opportunities (PMBOK, 2008)

Rules of performance measurement.

Earned value management (EVM) rules or other physical measurement rules of performance measurement are set. For example, the schedule management plan may specify:

- Rules for establishing percent complete,
- Control accounts at which management of progress and schedule will be measured,
- Earned value measurement techniques (e.g., baselines, fixed-formula, percent complete, etc.) to be employed (for more specific information, refer to the

- Schedule performance measurements such as schedule variance (SV) and schedule performance index (SPI) used to assess the magnitude of variation to the original schedule baseline.

The information is based on the projects past performance and expected future performance, and includes earned value performance indicators that could impact the project in the future.

The three parameters of planned value, earned value, and actual cost can be monitored and reported on both a period-by-period basis (typically weekly or monthly) and on a cumulative basis. Figure 2-15 uses S-curves to display EV data for a project that is performing over budget and behind the schedule.

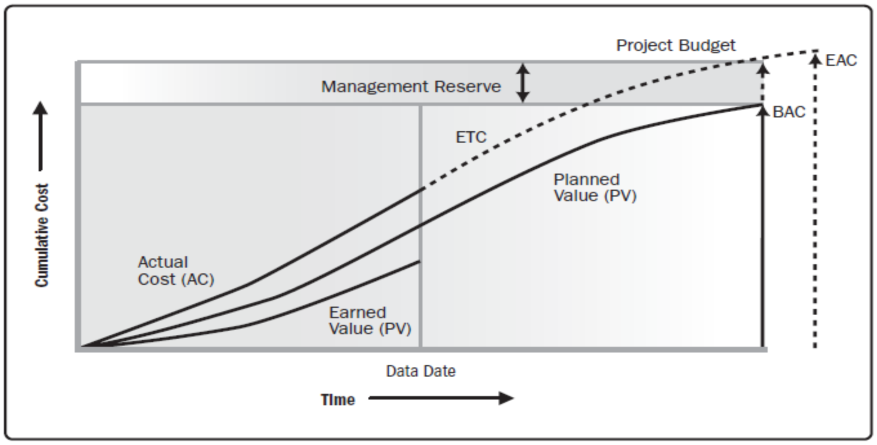

Figure 2-15 Earned Value Analysis S curve (Adopted from PMBOK, 2008)

Performance reviews compare cost performance over time, schedule activities or work packages overrunning and underrunning the budget, and estimated funds needed to complete work in progress.

Variance analysis

Variance analysis, as used in EVM, is the explanation (cause, impact, and corrective actions) for cost (CV = EV – AC), schedule (SV = EV – PV), and variance at completion (VAC = BAC – EAC) variances. Cost and schedule variances are the most frequently analyzed measurements. Variance analysis can be performed to determine the cause and degree of variance relative to the schedule baseline and any corrective or preventative actions needed. Cost performance measurements are used to assess the magnitude of variation to the original cost baseline. An important aspect of project cost control includes determining the cause and degree of variance relative to the cost baseline and deciding whether corrective or preventive action is required. The percentage range of acceptable variances will tend to decrease as more work is accomplished.

Trend analysis

Trend analysis examines project performance over time to determine if performance is improving or deteriorating. Graphical analysis techniques are valuable for understanding performance to date and for comparison to future performance goals in the form of BAC versus EAC and completion dates.

Earned Value Analysis					
Abbreviation	**Name**	**Lexicon Definition**	**How Used**	**Equation**	**Interpretation of Result**
PV	Planned Value	The authorized budget assigned to scheduled work.	The value of the work planned to be completed to a point in time, usually the data date, or project completion.		
EV	Earned Value	The measure of work performed expressed in terms of the budget authorized for that work.	The planned value of all the work completed (earned) to a point in time, usually the data date, without reference to actual costs.	EV = sum of the planned value of completed work	
AC	Actual Cost	The realized cost incurred for the work performed on an activity during a specific time period.	The actual cost of all the work completed to a point in time, usually the data date.		
BAC	Budget at Completion	The sum of all budgets established for the work to be performed.	The value of total planned work, the project cost baseline.		
CV	Cost Variance	The amount of budget deficit or surplus at a given point in time, expressed as the difference between the earned value and the actual cost.	The difference between the value of work completed to a point in time, usually the data date, and the actual costs to the same point in time.	CV = EV – AC	Positive = Under planned cost Neutral = On planned cost Negative = Over planned cost
SV	Schedule Variance	The amount by which the project is ahead or behind the planned delivery date, at a given point in time, expressed as the difference between the earned value and the planned value.	The difference between the work completed to a point in time, usually the data date, and the work planned to be completed to the same point in time.	SV = EV – PV	Positive = Ahead of Schedule Neutral = On schedule Negative = Behind Schedule
VAC	Variance at Completion	A projection of the amount of budget deficit or surplus, expressed as the difference between the budget at completion and the estimate at completion.	The estimated difference in cost at the completion of the project.	VAC = BAC – EAC	Positive = Under planned cost Neutral = On planned cost Negative = Over planned cost
CPI	Cost Performance Index	A measure of the cost efficiency of budgeted resources expressed as the ratio of earned value to actual cost.	A CPI of 1.0 means the project is exactly on budget, that the work actually done so far is exactly the same as the cost so far. Other values show the percentage of how much costs are over or under the budgeted amount for work accomplished.	CPI = EV/AC	Greater than 1.0 = Under planned cost Exactly 1.0 = On planned cost Less than 1.0 = Over planned cost
SPI	Schedule Performance Index	A measure of schedule efficiency expressed as the ratio of earned value to planned value.	An SPI of 1.0 means that the project is exactly on schedule, that the work actually done so far is exactly the same as the work planned to be done so far. Other values show the percentage of how much costs are over or under the budgeted amount for work planned.	SPI = EV/PV	Greater than 1.0 = Ahead of schedule Exactly 1.0 = On schedule Less than 1.0 = Behind schedule
EAC	Estimate At Completion	The expected total cost of completing all work expressed as the sum of the actual cost to date and the estimate to complete.	If the CPI is expected to be the same for the remainder of the project, EAC can be calculated using:	EAC = BAC/CPI	
			If future work will be accomplished at the planned rate, use:	EAC = AC + BAC – EV	
			If the initial plan is no longer valid, use:	EAC = AC + Bottom-up ETC	
			If both the CPI and SPI influence the remaining work, use:	EAC = AC + [(BAC – EV)/(CPI x SPI)]	
ETC	Estimate to Complete	The expected cost to finish all the remaining project work.	Assuming work is proceeding on plan, the cost of completing the remaining authorized work can be calculated using:	ETC = EAC – AC	
			Reestimate the remaining work from the bottom up.	ETC = Reestimate	
TCPI	To Complete Performance Index	A measure of the cost performance that must be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the budget available.	The efficiency that must be maintained in order to complete on plan.	TCPI = (BAC – EV)/(BAC – AC)	Greater than 1.0 = Harder to complete Exactly 1.0 = Same to complete Less than 1.0 = Easier to complete
			The efficiency that must be maintained in order to complete the current EAC.	TCPI = (BAC – EV)/(EAC – AC)	Greater than 1.0 = Harder to complete Exactly 1.0 = Same to complete Less than 1.0 = Easier to complete

Table 2-6 Earned Value Analysis formulas (Adopted from PMBOK, 2008)

2.5.5 Lessons Learned

Experience and History from past projects support decision-making and increase organizational performance. This is called “lessons learned” by project literature and practitioners. The term defines the practice of learning from successful and unsuccessful past events. Martin & Martin (2003) defined, “Lessons learned are key project experiences which have a certain general business relevance for future projects. They have been generated by a project team and represent a consensus on a key insight or knowledge that should be considered in future projects”. Further, Jugdev (2012) concluded “Lessons learned is an efficient and effective way of transferring valuable project knowledge-the good, the bad and the ugly to rest of the organization”. Also PMBOK (2008) defines Lessons learned as “The knowledge gained during a project which shows how project events were addressed or should be addressed in the future with the purpose of improving future performance”. In all of these definitions the main focus area is ‘knowledge gained from previous executed projects’ i.e. the history of the project.

The lessons-learned strategy seeks to share knowledge about the elements that did / did not go according to plan, the parts that could be improved, and the plans/strategies to address these issues (Jugdev, 2012). These practices have been empirically proved and the actual benefits are higher than expected (Flyvbjerg, 2006). The knowledge gathered by assessing project events in post-project reviews can dramatically narrow the cone of uncertainty in future projects. Despite having a remarkable potential to reduce variability in future project, it is clear that

- In general, the knowledge and lessons learned derived from a project are not systematically incorporated in the development of subsequent projects (Williams, 2008)
- Actual techniques used to transfer the information (mainly verbal feedback systems among a limited group) do not accomplish their goal ((Williams, 2004).
- In practice, the “lessons learned” process frequently ends with capturing the outstanding events or collecting only good things. Once the project is finished it might be difficult to find where this information is.
- The likelihood of reusing lessons learned depends on the availability, applicability to future projects and the similarity between projects.

2.5.5.1 Lessons Learned and Organizational Performance

Projects are by nature a sort of temporary organizations, which develop temporary and unique processes with non-routine features and produce ‘learning’. Moreover, projects deal with several organizational functions and the knowledge produced is unique and created in the context of application (Williams, 2008). In addition to these internal characteristics, projects involve multiple challenges and are influenced by external factors such as competition, alliances, contractual issues, time, etc. (Jugdev, 2012). All these above aspects are part of the uncertainty sources along project-based organizations. In consequence, strategies are needed to mitigate the risks and organizations shall exploit the opportunities derived from the uncertainty. The organizational performance can be improved by addressing these uncertainties. The advantages of lessons learned are summarized below.

2.5.5.2 Advantages of Lessons Learned

- Organizations can achieve results at the operational level.

- Company's competitive advantage based on the knowledge-based practices is enhanced (Jugdev, 2012).
- Money saved is money earned. Its calculations may also be indirect through improvements in measures like life cycle time, customer satisfaction and process improvements or even calls averted (Davenport, De Long, & Beers, 1998).
- Formal/ informal workplace learning and explicit technical knowledge sharing is enabled (Jugdev, 2012).
- No extra costs due to redundant work and repetition of mistakes. Work can be 'REUSED'. Customer and user satisfaction will be higher.
- Continuous learning and improvement are set as the highest level of project management and organizational maturity.
- The knowledge and experiences are collected and could be shared across the organization when necessary.

All organizations shall display attentiveness in learning and improve from one project to the next. The possibility to compare and learn from one project to the next, in terms of both efficiency and effectiveness, with the argument that every project is unique might just be a pretext for not dealing with overall project organization performance (Andersen S Erling, 2006). The sustainability of the organizations cannot be predicted.

3 Model Framework & Analysis

In this chapter, the author has developed models for estimation process with a feedback loop, lessons learned process and historical data utilization process. The generic models which can be used for any organization are developed based on the work from previous literature. Each phase of the models has been analyzed in detail and the roles and responsibilities for individual phases have been defined.

3.1 Estimation process with a feedback loop Model

The estimation models like parametric or algorithmic models are mostly computerized, which contain algorithms, rules, inferences and mappings. Once calibrated to a particular environment, cost estimation becomes more scientific because the process is more repeatable. Moreover, these models can only aid the cost estimator and cannot replace them (Stensrud & Myrtveit, 1998). Cost estimators have to use their judgement concerning the validity of calibration data during the input of parameter values. For example, parametric cost models are often built on underlying assumptions and relationships between variables, which do not necessarily reflect reality (Beltramom, 1988) (Stensrud & Myrtveit, 1998). Hence, it is the cost estimators and their expertise that ultimately control the output of any cost model (Rush & Roy, 2001).

Furthermore, used judgements and assumptions can influence the results significantly. Therefore, although cost models are designed to facilitate the generation of estimates, they can only reflect a realistic cost with the input of expertise and judgement of the users. It should be noted that companies feel more comfortable with the use of algorithmic and computerized models than they do with Expert Judgement (Hughes, 1996). Hughes (1996) argues that organizations should not take such a negative view with respect to the use of Expert Judgement. Rather, that companies should acknowledge it, and develop cost models and information systems that attempt to support it. The following process acknowledges how an expert judgement and estimation model is integrated into the estimation process.

3.1.1 Description of Estimation Process with Feedback Loop

The Estimation models described in Section 2.4.4 are not enough to solve the issues arise due to different constraints defined in Section 0. Certainly, the estimation models developed from past projects are the core of estimation process, whether the model is described through mathematical equations (e.g. parametric estimation) or expert judgement approach.

Many researchers build their models using data from completed projects i.e. historical data. This means they start with a set of known facts which do not have uncertainty.

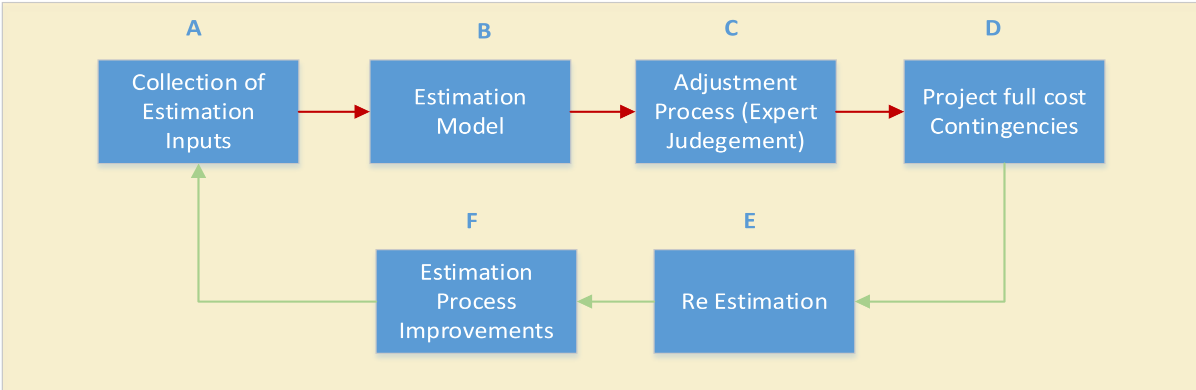

Figure 3-1 Estimation process feedback loop (Outline)

Figure 3-1 depicts steps of the estimation process with feedback loop at outline level, while Figure 3-2 depicts the detailed level of estimation process. The process is divided into 6 phases. Each of these phases is described below. The estimation process was developed based on software cost estimation process suggested by (Abran, 2015). In the following figures the red line represents the forward process and the green line represents the feedback loop.

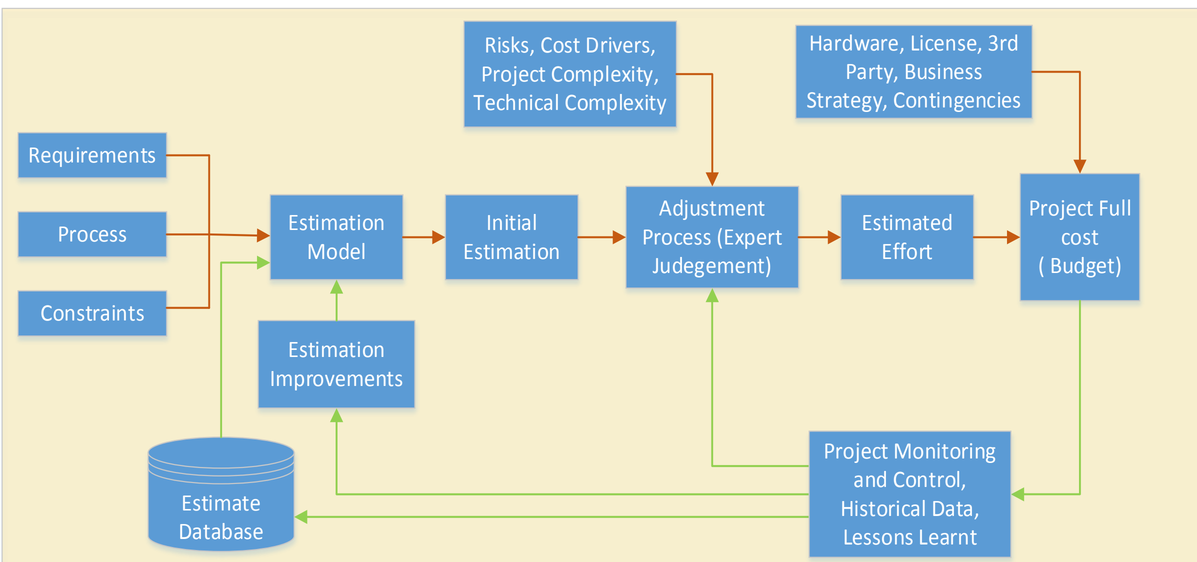

Figure 3-2 Estimation process feedback loop (Detailed)

A: Collection of Estimation Inputs

As ‘collection of estimation inputs’ is the first step in the estimation, the required input data which includes cost drivers like resources, processes, requirements and products for a specific project shall be identified.

The value of the constraints that shall be identified since the nature of these inputs is uncertain at the time of an estimate is prepared. Further, the uncertainty associated with these inputs should be documented. For any project or project estimate, there are 6 important constraints shall be considered: they are Scope, Time, Cost, Risk, Resource and Quality (Karen, 2016). As these constraints are interrelated, an issue on one of the constraints will affect one or more of the other constraints.

Figure 3-3 Project Constraints

The constraints are depicted above in Figure 3-3.

The estimation input requirements are:

- The functional requirements which can be measured with any of the international standards for functional size measurements.
- The nonfunctional requirements which are typically in a textual description.
- The relationship between functional and nonfunctional requirements.

In addition, the expected characteristic of the process and implementation system, technology, standards etc. shall be defined.

B: Execution of Estimation Model

There are 2 steps in this execution:

Step1: Use of estimation model as a simulation model usually considers only the estimated values of the inputs. It is to be noted that the uncertainty of input is not considered here. Equation in the estimation model produces a theoretical single estimate. The information on the performance of the estimation models can be used to expect range of variation (Based on the historical data or previous estimations) (Dysert, 1999).

The selection of the model is affected by the following cost related factors

- The time taken to develop a new model
- The cost involved in additional data storage equipment
- The time taken to do the modelling (Opportunity Cost)
- The time taken to do a model selection

Step2: The information about the uncertainty documented in Step1 can be summed up with the expected range of variation of the model. Eventually the output of estimation model increases range of variation. The variation depends upon the confidence levels of the inputs and estimation model.

As mentioned before, the estimation models discussed in Section 2.4.4 include number of independent variables. The key independent variables that need to be used in the estimation model shall be decided for using in the adjustment process which is discussed below. They may not be necessarily known with certainty at this point. So the estimators are expected to assess the quality of the information available to quantify such inputs which shall always be documented for future use. The quality could give a value of uncertainty before an estimation model is used.

C: Adjustment Process

The adjustment process is the process used to take care of certain factors, cost drivers and variables as the estimation process cannot directly use the output of the estimation model because of the following reasons:

- The estimation model typically includes only a limited number of independent variables that are explicitly used in mathematical models.
- There are certain factors which might not have historical data, the risk factors and constraints that impact the project life cycle.

As mentioned the adjustment process takes care of all these factors. The estimators have to investigate these factors, cost drivers and key independent variables. Some of the factors are listed below (McConnell, 2006).

- Project complexity
- Technical complexity
- Risks and probability of occurrence
- Assumptions
- Experience of the employees
- Experience of the employees in that particular job
- Usage of support tools for design and testing.

The adjustment process is normally based on expert judgment and affects the theoretical estimation of the estimation model. It is possible to make qualitative information using adjustment process such as (Michael, 2003)

- An optimistic estimate (A lowest cost or duration)
- A most likely estimate (With a low probability of occurrence)
- A pessimist estimate (The highest expected cost or duration)

The above estimated effort value are the output of the adjustment process, which will be used for project full cost and project resource allocation.

D: Project Full Cost

The next phase in the estimation process is selecting a specific effort value or proposed set of values from the adjustment process and allocating the values to the project. The project budget decision is made in this phase. The other costs related to hardware and 3rd party cost are added in this phase. Further, setting aside a contingency fund helps to avoid constraints in this phase. The pricing model also can be selected.

The selection of a specific value depends on strategies of the business. It can depend on customer and discounts to customer. At this point a collective decision by number of sales/ tender managers and top management help to avoid future risks. The decision on full cost of a specific project should not be based on the result of an estimation model alone.

According to Abran (2015), choosing a pessimistic estimate might result in failure to get the job and overspending can occur. Choosing an optimistic approach may almost lead to cost overruns and to shortcuts being taken. Therefore in practice most likely scenario is often selected. It is also perceived to have greatest chance of being accurate.

To avoid the problems due to underestimations, estimation must include contingency funds. According to PMBOK (2008), "contingency fund is the amount of funds, budget, or time needed above the estimate to reduce the risk of overruns of project objectives to an acceptable level of organization. Contingency funds meant to cover a variety of possible events and problems that are not specifically identified, or to account for a lack of project during the preparation of planning estimates".

E: Re-estimation

Whatever the estimation model or process used there is always uncertainty in the estimation. So the projects must be monitored to verify whether or not they are progressing as planned, with respect to budget, schedule and quality. Whenever there is a major changes in scope or schedule re-estimation shall occur.

When a project goes significantly off-track and is greatly overshooting its budget, and there is a chance of missing project dead line, the project must obviously be re-estimated. And then a number of constraints must be handled and decision must be taken as follows (Nasa, 2015):

- Increase the budget by re-estimating, while keeping the same deadline and same scope.
- Increase the budget by re-estimating, to deliver the same scope, but postponing the deadline.
- Stay within the budget, but postpone a number of functions to a later project phase.
- Stay within the budget and dead line, but skip some quality controls.
- And so on.

The project managers' preference among the above options is crucial to decide on further proceedings.

F: Estimation improvements

This phase shall be undertaken at organization level and not at the project level. It involves analyzing the performance of estimation process and estimation models. In addition it shall be taken up once each project is completed.

The estimation process or estimation models improvements are based on

- The data collected at the completion of a project when there exists no longer uncertainty about project deliverables (No. of documents or packages delivered, Quality levels achieved, Duration, Used effort data).
- The skills of the people integrating collected data into estimation models to improve them.

3.1.2 Roles & Responsibilities

Table 3-1 presents the roles and responsibilities of the estimation process. The responsibilities of individual resources are outlined below. It is assumed that the responsibilities are applicable only for the estimation process

Step	Estimation Process Step	Responsible Group	Responsible Person
A	Collection of Estimation Inputs	Sales	Sales/ Tender Manager Sales Engineering
B	Execution of Estimation Model	Sales	Sales/ Tender Manager Sales Engineering
C	Adjustment Process	Sales Project Management	Sales/ Tender Manager Project Manager Expert Lead Engineer
D	Project Full Cost	Sales Project Management Operations Group	Sales/ Tender Manager Project Manager Top Management
E	Re-estimate	Project Management	Project Manager Lead Engineer
F	Estimation Improvements	Operations Group	Operations Manager

Table 3-1 Roles and responsibilities in Estimation process

Sales Engineer Responsibilities:

- Building the estimation models
- Collecting data from past projects
- Building relationship between different variables
- Documenting quality of the Estimation models
- Communicating with the Experts and Lead engineers to get the feedback on estimation models
- Feeding the input requirements into the estimation models and document range of solution
- Carrying out adjustment process together other team

Sales/Tender Manager Responsibilities:

- Collecting the risks and constraint inputs
- Analyzing the solutions for the risk and constrains and apply them to estimate
- Preparing the assumption
- Communicating with customer and project manager.
- Making an optimal decision together with the project manager and operation management
- Committing to a single estimate
- Selecting pricing model

Project Manager Responsibilities:

- Participating in the adjustment process and full cost to check if there any aspects are missing in estimation
- Verifying resource availability
- Verifying effort and schedule data
- Communicating with customer during execution if any changes required to estimation
- Providing feedback to estimation process

Operation management/ Top management Responsibilities:

- Considering portfolios of all the projects for estimation models and process
- Considering the estimated costs, benefits, risks in terms of organization point of view
- Selecting pricing model based on market strategy
- Considering the strategy, organizational performance factors
- Supporting the initial data collection and data analysis for building initial estimation model
- Allocating of resources for training and estimation processes

3.2 Lessons Learned Process Model

In projects when somebody encounters some issues or problem, people often say 'Didn't we have the same problem earlier?', 'I know ABC had encountered same problem in his project', 'I really wish we have learned our lessons from their experience ','XYZ has solved this problem and we can contact him'. These kind of problems and solutions are hard to find in the document or somewhere in proper location which can be accessed by everybody. Lessons are really not learned until relevant process assets have been improved and the process has been institutionalized (Midha, 2009).

The challenges in capturing lessons learned are

- Employees don't have time to share their knowledge/ experience as they have business and targets to meet.
- Organizations are multi-functional. So it makes it difficult for effective communication.
- Culture and cultural diversity of organizations.
- Geographical distribution of organizations.
- Capacity and infrastructure to learn and adapt.
- Extracting knowledge from the experts (Kartam, 1996).

In today's competitive environment, organizations cannot afford to miss the opportunities and repeated mistakes. So, organizations must

- Quickly leverage from all the employee experiences.
- Provide organizational, cultural, and technological infrastructure to facilitate cross-team learning.
- Establish a proper process for capturing and storing lessons learned.

Therefore, there shall be a proper process established for capturing lessons learned and organizations must use it to increase their performance. The author has suggested following improvements of lessons learned process for capturing lessons learned. A 6 step process was developed based on a 5 step process suggested by Capability Maturity Model Integration (CMMI) (Midha, 2009) to:

- Conduct a periodic review of the effectiveness and suitability of the organizational process assets (CMMI, 2010).
- Obtain feedback about use of lessons learned process.
- Derive lessons learned.
- Make lessons learned available.
- Appraise the process, methods, and tools in use and make recommendations for improvement.
- Manage process improvement proposals.
- Establish organizational culture effectively.
- Support top management for decision making.

3.2.1 Description of Lessons Learned Model

The approach of 6 step process presented in Figure 3-4 can be used to improve the lessons learned process and eventually organizational performance.

A. Establish Infrastructure

- Create a single learning/knowledge repository to store the Lessons Learned. The repository should be
  - Searchable or Sortable by key project attributes such as Name, Customer, Plants, Systems, Type, Size, Phase, Functional area, Commercial, Technical and any other key words.
  - Easily accessible, Web-based, Secure, Access control.
- Create Training material.
- Create plan for deployment.
- Establish preliminary procedures.

A single repository for the entire organization has several benefits. It will make easier to quickly and easily identify pattern of similar projects. It is easier for anybody to look and search one common repository instead of going into several project document databases. Maintenance of the repository is very easier and the resources can be utilized efficiently.

B. Communicate and Deploy

The lessons learned process shall be communicated throughout the organization. The process needs to be informed to every individual employee via, Email Notification, Organizational meetings and Organizational newsletters. Organizations need to make training arrangements for each and every employee (Not just to Managers or Group leaders). This step brings information and management focus to the every employee. It also encourages every employee to submit and retrieve lessons learned from the repository. The process encourages improvements and innovations. Organizations need to make sure the process is advertised enough and then it shall be deployed for the usage.

When any process is reviewed and modified based on the feedback, it should be started from this phase of communicate and deploy.

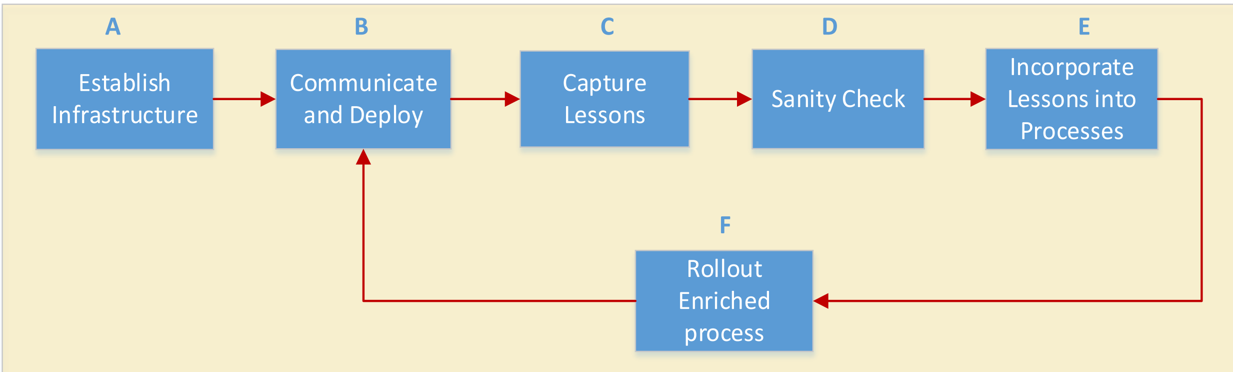

Figure 3-4 Lessons Learned improvement process

C. Capture Lessons

Lessons learned is generally captured at the end of every project. If the project lasts for longer durations employees often forget relevant information. So, instead of capturing the lessons at the end of the project, it is recommended that organizations shall make it compulsory to register the lesson learned during the entire life cycle of the project. This also helps the organizations to keep the knowledge if they need to lose the employees. In addition employees' needs to be encouraged to capture lessons in terms of both -what particularly worked well and what did not.

Capture lessons learned that address the following (Jugdev, 2012):

- Process - Defined process and the organizational standard process (i.e., processes, procedures, standards, methodologies, templates, and guidelines.)
- People - Project and organizational staffing and training (e.g., loading, availability, skill mix) and training (e.g., available, required, provided, needed, etc.)
- Tools/Technology - Organizational tools and equipment (e.g., statistical analysis/reporting tools, revision handling, simulators, databases, software, hardware, etc.)

D. Sanity Check

Sometimes the data entered by the employees might not be in a proper format or the solutions need to be reevaluated. So it is necessary to perform a sanity check periodically. ISTQB (2016) defines "A sanity check is a basic test to quickly evaluate whether a claim or the result of a solution can possibly be true. It is a simple check to see if the lessons learned entry is rational (that the case creator was thinking rationally by applying sanity)". The point of a sanity check is to rule out repeated or duplicated information. At the same time it can be made searchable by adding key words if necessary.

At the same time the impact/outcome of the lessons learned can be divided and defined how future projects may be affected:

Beneficial - Lesson learned from an actual project event with advantageous outcome (Positive). This information could be beneficial for other projects in the same organizational function.

Detrimental - Lesson learned from an actual project event with adverse consequences (Negative). This information could be beneficial for other projects in the same organizational function.

Good Practice - This is a process or practice observed in a project resulting in a positive outcome (i.e., success story) that should be considered as a “best practice” within the organization. Communications relating to good practice lessons learned are extended to entire organization.

E. Incorporate Lessons into processes

The lessons learned process itself works as a feedback system. This phase can identify (Williams, 2008):

- Lessons reported by employees, which can be incorporated into the process.
- Process which exhibits a pattern of belonging to a similar problem or solution.
- Solutions that have been successfully piloted in another project.
- Solutions that have relatively lower process overhead or lesser risk in changing the process.
- Solutions that can optimize and increase the efficiency.

All the organizational processes can be improved by incorporating the lessons into them. Improving the processes means one or more of the following (Perminova, 2011):

- Enhancing planning templates
- Enhancing checklists
- Introducing additional process activities/steps
- Making steps optional or mandatory
- Changing sequence of certain activities
- Suggesting use of new tools/technologies
- Introducing additional inspections or reviews
- Changing focus of certain activities
- Improving tailoring criteria and/or choices
- Collecting additional measurements

A. Rollout Enhanced Process

Improved processes need to be announced and released periodically as rollouts in various modes, especially highlighting changes in processes. The lessons already incorporated in the process assets need to be archived. The repository shall be accurate, concise and current.

The rolled out process connects back to the phase of communicate and deploy (B). This step will make sure that the employees understand the importance and focus of management on the processes. Further, the step will also enhance organizational ‘continuous learning’ process.

3.2.2 Roles and Responsibilities in Lessons Learned Process

Table 3-2 presents different steps involved in respective roles and responsibilities in lessons learned process.

Step	Lessons Learned process Step	Responsible Group	Responsible
A	Establish Infrastructure	Organization's Management	Top Management
B	Incorporate Lessons into Process	Operations group	Top Management Operation Managers
C	Capture Lessons	Sales, Project Management, Engineering, Supply Chain, Administration, Finance	All the roles in organization
D	Sanity Check	All the groups under guidance of Operations	Experts and Specialists in respective groups.
E	Incorporate Lessons into Process	Operations group	Operation Managers
F	Rollout Enriched Process	Operations group	Operation Managers

Table 3-2 Roles and Responsibilities in Lessons Learned Process

3.3 Historical Data Utilization Process Model

The details of historical data and its role in organizational performance is already discussed in Section 2.3 Project Historical Data. The present section deals with the model of historical data utilization process.

Collecting the project data is a relatively simple process assuming that all of the project relevant enablers (e.g. Data collection and analyze systems, etc.) have been put in place and the project costs have been properly recorded in the respective system. For capturing the data standardized project cost collection activities should be developed. This is to ensure that the data is uniformly organized so that nothing is overlooked during the collection.

The collection and analyzing the historical data for the projects is a vital step towards improvement of the accuracy of the estimations. The collected data should include information on both projects and process by which these products and services are built. For efficient collection of historical data, the following metrics must be customized for each organization generally:

- Basic characteristics of the development process in order to understand the context in which the system was developed.
- All estimates and re-estimates for the project.
- Actual costs of the final system. This metric must clearly indicate what was included.
- Characteristics of the completed product or service. This must include size and complexity metrics, description of the final product and service, classification of system, and other information that can be useful in developing cost estimation models for a given organization.

- The data must be collected in a form that is easy to access and analyze and in enough detail to be useful to the future estimation process.

3.3.1 Description of the Historical Data Utilization Process

Cross Industry Standard Process for Data Mining, commonly known by its acronym CRISP-DM is a data mining process model that describes commonly used approaches to tackle problems by data mining experts (Peter, et al., 2000). The process model is complicated and includes several steps. For the present work, the current author developed a model by modifying existing CRISP-DM data mining process model and adopted to the purpose of using the historical project data for organizational performance improvement. The modified process is shown below in Figure 3-5. The process model has 5 phases, each phase consists of several sub steps, which are defined in the description given below.

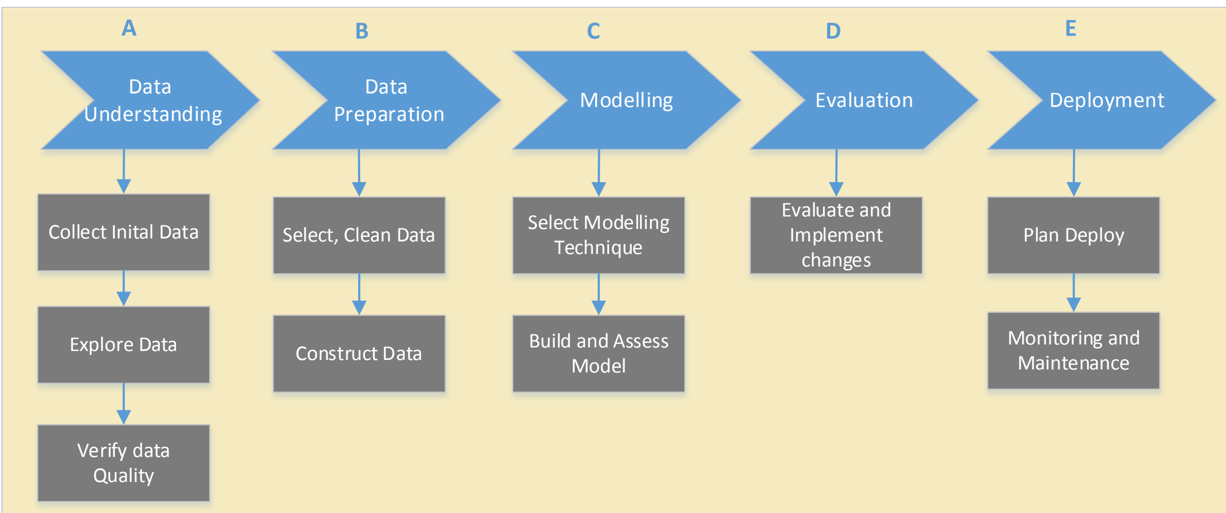

Figure 3-5 Historical data utilization process model

A: Data Understanding

The data understanding phase starts with initial data collection and proceeds with activities that enable to become familiar with the data, identify data quality problems, discover first insights into the data, and/or detect interesting subsets to form hypotheses regarding hidden information (Peter, et al., 2000). The sub phases of data understanding are to:

- Acquire the data or the access to the data listed in the project resources. The method used to acquire data shall be documented and recorded any problems while collecting the data.
- Identify the key attributes of the data and relation between different fields.
- Examine the quality of the data, addressing questions such as: Is the data complete (does it cover all the cases required)? Is data correct, or does it contain errors and, if there are errors in data, how common are they? Are there any missing values in the data?

B: Data Preparation

The data preparation phase covers all activities needed to construct the final dataset (data that will be fed into the modeling tools) from the initial raw data. Data preparation tasks are likely to be performed multiple times and not in any prescribed order. Tasks include table, record, and attribute selection, as well as transformation and cleaning of data for modeling tools. The sub phases of data preparations are to (Peter, et al., 2000):

- Decide on the data to be used for analysis. Data selection covers selection of attributes (columns) as well as selection of records (rows) in a table.
- Raise the data quality to the level required by the selected analysis techniques. This may involve selection of clean subsets of the data, the insertion of suitable defaults, or more ambitious techniques such as the estimation of missing data by modeling.
- Combine data from multiple tables or records to create new records or values. Merged data covers aggregations. Aggregation refers to operations in which new values are computed by summarizing information from multiple records and/or tables.

C: Modeling

In this phase, various modeling techniques (E.g. Bottom-up, Top-down) are selected and applied, and their parameters are calibrated to optimal values. Some techniques have specific requirements on the form of data. Therefore, going back to the data preparation phase is often necessary. The sub phases of modeling are to:

- Select the actual modeling technique that is to be used.
- Run the modeling tool on the prepared dataset to create one or more models. With any modeling tool, there are often a large number of parameters that can be adjusted. The parameters and their chosen values have to be listed along with the rationale for the choice of parameter settings.
- Assess the model according to requirements. According to the model assessment, parameter settings are revised and tuned for the next test.

There are variety of statistical methods to be applied for modeling. If one is not skilled enough here, at this point it shall be quite important to involve some experts and ask them to potentially help with understanding of data and prognosis.

D: Evaluation

Before proceeding to final deployment of the model, it is important to thoroughly evaluate it and review the steps executed to create it, to be certain the model properly achieves the objectives. A key objective is to determine if there are some important business issues that have not been sufficiently considered. The sub phases of evaluation are to:

- Determine if there are any business reasons why this model is deficient. Apply the model on pilot project in the real application, if time and budget constraints permit.
- Summarize the process review and highlight activities that have been missed and those that should be repeated.

E: Deployment

It often involves applying “live” models within an organization’s decision making processes for example, real-time personalization of Web pages or aggregating the historical data. Depending on the requirements, the deployment phase can be as simple as generating a report or as complex as implementing a repeatable data process model across the organization. The sub phases of deployment are to (Peter, et al., 2000):

- Evaluate results and determines a strategy for deployment. If a general procedure has been identified to create the relevant model, this procedure is documented for later deployment.
- Summarize the monitoring and maintenance strategy, including the necessary tasks and how to implement them.

3.3.2 Roles & Responsibilities

The historical data utilization process generally is a difficult process and might needs to properly assess the organizational processes, infrastructure, systems and etc. Therefore organizations need to assess themselves if it is right investment to do implementation of the historical data process or to approach an expert third party supplier to build the process. The operations group and top management are responsible for building and using this process.

The following roles are required for achieving an accurate historical database process and system (Todd & Bruce, 2007).

- **Software development experts:** When the organization has taken a decision to establish a new historical database system and process, it requires software developers. Many companies have very limited software development resources as staff. Contracting a consultant companies who understands the organization needs and can also provide development services is an alternative. These service providers help to determine the requirements, provide enhanced specification writing, and then create custom software to meet organizational needs.
- **Data analysis experts:** Whether the organizations develop system in-house or hire it out, they need resources who can expertly analyze the data that has been collected. As mentioned most companies do not have these experts as staff. Hiring data analysts who understand, interpret, organize, and filter the data that is collected would be a viable solution.
- **Experienced decision making:** Consultants that specialize in providing these services have considerable experience and have usually been in the project business for many years. But the organization needs to take efficient decisions during development phase by operations group and top management.

4 Case study in ABB

This chapter introduces the case study conducted in the company ABB. The chapter starts with an introduction and organizational structure of ABB. Subsequently the chapter defines the existing practices, processes and tools used in ABB. The sales processes, estimation models, complexity of project definition, historical data format and KPIs used in ABB are also explained. The chapter also provides details of the interviews from experts in ABB. Further it provides the structure of the questionnaire of interviews. The interview results gathered from diverse topics are presented.

4.1 ABB Introduction

ABB is a pioneering technology leader that works closely with utility, industry, transport and infrastructure customers in roughly 100 countries. With more than four decades at the forefront of digital technologies, ABB is a leader in digitally connected and enabled industrial equipment and systems with an installed base of more than 70,000 control systems connecting 70 million devices. With a heritage of more than 130 years, ABB operates in more than 100 countries with about 135,000 employees.

Innovation is ingrained in the DNA of ABB. ABB was chosen by Thomson Reuters as one of the planet's top 100 Innovators.

ABB (ABBNO, 2015) AS Norway operates as a subsidiary of ABB Ltd. ABB Norway has vast range of customers. They have very big install base of electrical and control system products in the Norwegian offshore continental shelf. ABB’s Process Automation Division (PA) is a leading provider of fully engineered solutions and products for process control, safety, instrumentation, plant electrification and energy management for the key process industry sectors of Chemical, Oil & Gas, Marine, Mining, Minerals, Metals, Cement and Pulp & Paper.

ABB (2016) explained their strategy as “there is the wider digital transformation that is happening across our group. With the introduction of ‘ABB Ability’, our execution model will need a rethink. We will not abandon proven principles of project execution; rather, we will look at the optimization that can come with better use of technology and collaboration tools. For this we have formed a "project factory" team that will secure best practices, more productive work processes and a harmonized execution methodology across our organization”. This is certainly one of ABB steps towards utilizing the historical data.

4.1.1 ABB AS Division

ABB has shaped its business into four organizational divisions. The divisional structure of ABB is shown in Figure 4-1. The divisions are Electrification Products, Robotics and Motion, Industrial Automation and Power Grids (ABB, 2016).

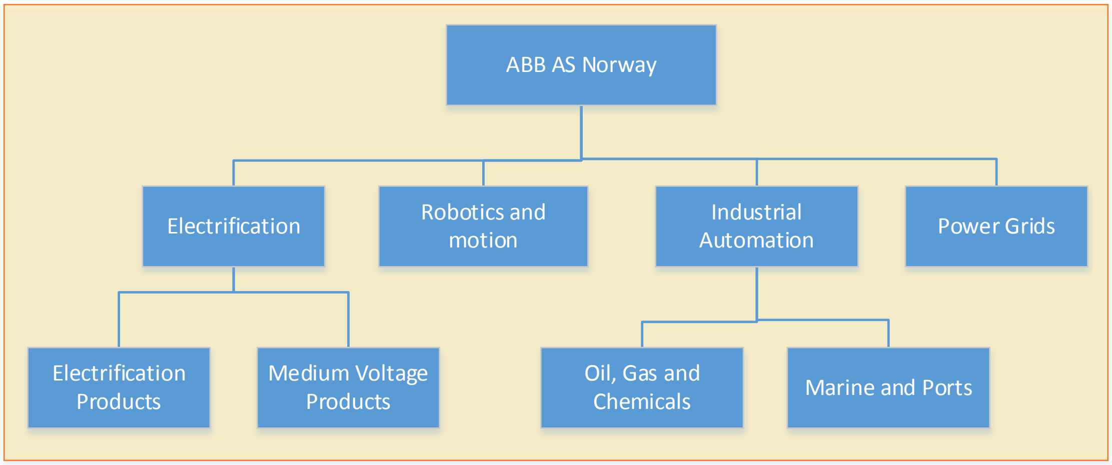

Figure 4-1 ABB AS Organizational Structure (Divisions) (ABB, 2016)

4.1.2 ABB AS Oil, Gas and Chemical Organizational structure

The Oil, Gas and Chemicals (OGC/PAOG) division focuses on opportunities in the upstream, midstream and downstream Oil, Gas and Chemical industries. This group belongs to Industrial Automation division as part of the ABB Group.

OGC division aspiration is to be their customers' first choice for intelligent, integrated, efficient and secure operations in all segments of the OGC value chain, across the scope delivered by the BU. Further, quality and consistency in execution, competitiveness are core foundations for their business.

OGC division is further divided into different business units as shown in Figure 4-2 importantly Sales/Tendering, Project execution, Engineering and Technology, Human Resource, etc.

OGC Operations is led by the BU OGC Operations Manager who reports to the BU director. BU OGC Operations is responsible for the global operational performance of the BU Operations organization. The operation function ensures functional leadership and maturity of the following functions within their BU: Supply Chain Management (SCM), Engineering, Project Execution (including project management and site management), Quality, Operation Excellence (Opex), Value Chain Excellence, White Collar Productivity (WCP), Manufacturing and BU Operations.

OGC Operations are responsible for establishing and maintaining common global processes and tools within the Operations functional areas, and working together with the Global BUs to ensure that the common processes and tools are implemented in the Global BUs.

Some of the BUs in ABB has target of lowering costs by 30% by 2018 by continuously improving capabilities which is a focus on organizational performance.

In summary ABB's organization structure is aligned with organization theory discussed in section 2.1. The relationship and interactions between the units of the business, divisions are clearly defined so that the chain of command runs through the different levels efficiently.

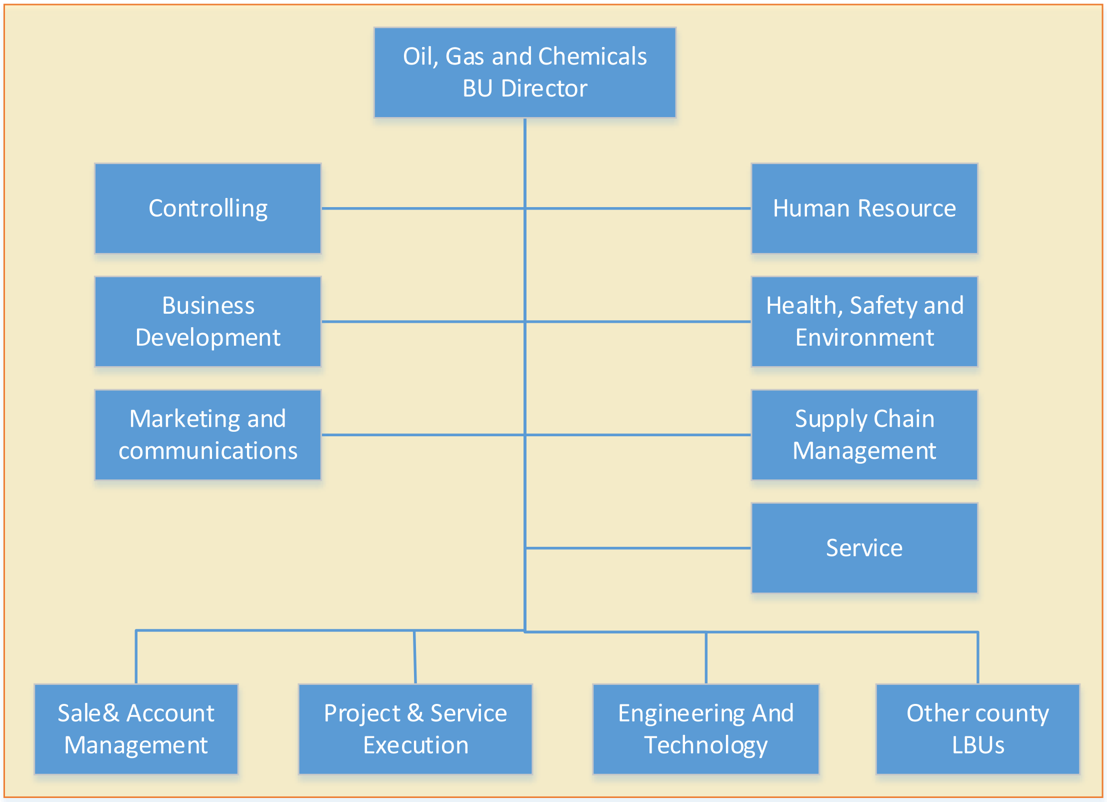

Figure 4-2 BUs of Oil, Gas and Chemicals organizational (ABB, 2016)

ABB recently launched Stage 3 of its Next Level strategy to unlock value for customers and shareholders. The core elements of this include: shaping ABB's divisions into four market-leading, entrepreneurial units, realizing ABB's full digital potential; accelerating momentum in operational excellence; and strengthening ABB's brand (ABB, 2016).

As part of the program ABB focused on organizational changes, portfolio changes and standardization and performed organizational performance activities given below by.

- Provide professional project execution capabilities.
- Designed to facilitate collaboration across the functions.
- Sharpened focus on project portfolio management to focus on markets
- Strengthen supply chain managements
- Established Professionalized support functions
- Established Comprehensive project governance structure.
- Portfolio management improvements to facilitate coordination on a level that enables them to specialize, further improve performance and identify new opportunities.
- Facilitated improved resource utilization.
- Increased focus on ownership and governance through the portfolios
- Common engineering process, covering all core disciplines and end-users, greenfield and brownfield
- Created standard document sets.

4.1.3 Management System-IMS

ABB AS holds a certified quality management system in accordance with ISO 9001:2008. The quality management system is available to all employees in the Integrated Management System (IMS), accessible through the company intranet via SharePoint site. Figure 4-3 depicts the IMS system webpages in ABB.

The IMS is both a repository for guiding documents and a process-oriented system streamlining the way ABB works. IMS is a step by step system guiding the employees through the various phases of a project or service delivery (ABB, 2016).

The system features harmonized web pages for all work processes, allowing smooth navigation and easy access to documents like procedures, instructions, checklists and templates. It also serves as a tool for gathering lessons learned to advance best practices.

The IMS is intuitive and user-friendly. The process-oriented approach upholds a uniform way of working regardless of the person or unit performing the task. Combined with tailor-made sites for projects, built-in project governance, easier retrieval of relevant documents and an integral system for collecting improvements. It is a strong collaboration solution which is crucial and can reduce cost to boost quality.

ABB Group Guidelines, organization's systems and processes are collected into one framework. The integration provides a platform to become a unified entity, with each function having its key performance indicators and targets for improvement. While it keeps the uniqueness for each business unit, it also simplifies the overall structure, makes the processes more efficient and gives uniformity for most aspects in organization performance and helps to control associated risks.

The IMS system is developed to increase the organizational performance

- Improve ABB's execution.
- Customer Statoil's STEP program and similar forced ABB to be more efficient
- Internal review programs indicated significant improvement potential in the content and usage of old quality programs
- The need for and strive for continuous improvements is an integral part of the IMS

The IMS system can achieve

- Consistency in high quality. To be repeated each time project executed.
- Faster and easier to find relevant procedures and templates and get the work done.
- Best practice harnessed through continuous improvement and knowledge sharing.
- Common work processes throughout the ABB AS.

Figure 4-3 ABB Integrated Management System

4.1.4 Project Governance

Project Governance is the mechanism by which ABB management provides direction and support to projects. Governance is exercised through various management roles, processes and standards and shall give ABB management the tools to efficiently support the projects and services by:

- Ensuring the right level of support at any given time during the life-cycle of a delivery
- Making sure that responsibilities are clearly defined and the governance processes are effective
- Ensuring that all aspects of a project's performance, such as health and safety, quality, financial, contractual, technical, internal development and customer satisfaction are systematically taken into account
- Ensuring that work is executed in accordance with all relevant ABB instructions and requirements
- Ensuring that information is easily available, especially information related to decision-making and coordination with other activities and projects

Through the phases of a delivery, starting in the sales and tendering phase, stage gate reviews are performed based on checklists developed as a part of the Governance Model procedures and instructions.

In addition to the above, ABB runs periodical project review meetings headed by the portfolio owner who acts as a project sponsor. The project sponsor is accountable for the project performance and customer satisfaction.

4.1.5 KPIs

Relentless execution (Relex) is an ABB Group's focus area and is part of the Next Level 2020 strategy. The objective is to align priorities in operations management and improve our operational performance.

Progress is tracked in a cross-functional dashboard (RED), which holds eight KPIs in four main categories; care, customer, cost and cash. The performance improvement of each division and BU are reviewed yearly according to a RED scoring system, in which the KPIs have been weighted and a maximum score of 100 dashboard points can be achieved.

- Care – Health & Safety
- Customer – Requested On Time Delivery, Customer Complaint Resolution Process, Warranty cases
- Cost – improvement projects, quality costs
- Cash – net working capital, inventory turnover

The Relex dashboard as shown in Figure 4-4 is representing most of the organizational performance factors.

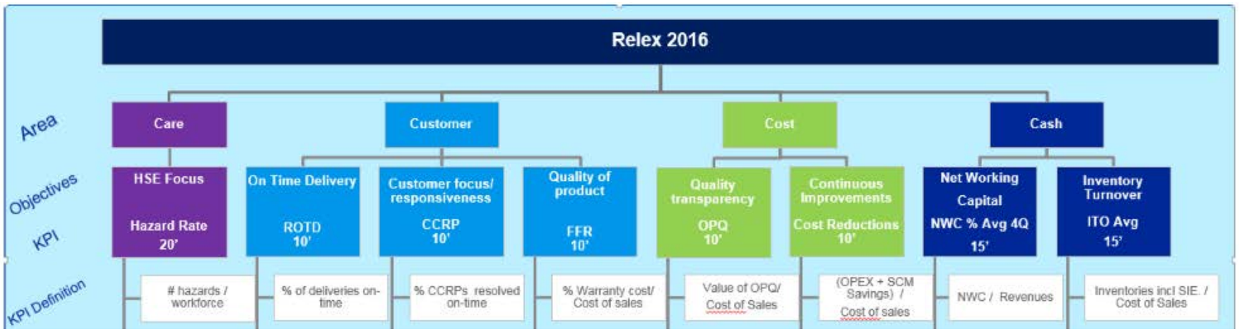

Figure 4-4 ABB Relex dashboard

The important purposes of Relex dashboard are

- Engage in quality initiatives that generate tangible benefits in support of ABB's Business goals.
- Use metrics to prioritize and drive improvement actions, key objectives being part of Relex.
- Use a disciplined problem solving methodology to prevent recurrence throughout the organization.
- Participation from employees to continually improve the processes and products.
- Involving stakeholders (internal/external) in providing feedback and validating the results for ABB improvement.

The KPIs created based on the Relex dashboard are

- Requested On-time Delivery (ROTD)
- Customer Complaint Resolution (CCRP)
- Quality costs (Opportunities for Perfecting Quality)
- Net Promoter Score (NPS)

- Lost Time Incident (LTI)
- Cost of Sales (COS)
- Supplier On-time Delivery (SOTD)
- Quality transparency Number of OPQs
- Number of new improvement projects (To achieve cost reduction)

All of the above KPIs have defined target values which are not mentioned in this document due to the sensitiveness of the information. As a whole ABB has good focus on KPIs, but they need to be stream lined through entire organization.

4.2 Sales and Tendering in ABB

4.2.1 Sales work process

The purpose of this process description is to provide information about how the sales/ tendering process is working from prospecting phase to all the way until handover to project (Closing) phase in ABB. The primary objective of the process is that business opportunities are developed according to business strategies, the winning probability is maximized and the lessons learned process is enabled completely.

The sales process provides valid instructions, guidelines and templates to use by sales department, but also serves as repository for knowledge sharing and improving the sales process.

Sales needs to be performed by all the employees in organization, who are interacting with the customers and market - not only the sales departments. As such, the processes defined by sales shall be used within the entire organization. It is the responsibility of the sales organization to develop & maintain customer relationship, market ABB offerings & solutions and provide sales tenders in response to customer inquiries. By understanding the market and its customers, the sales organization needs to lead the way for business development and technical innovation.

The sales process consists of 5 phases and in the beginning of each phase there is a Stage gate as shown in Figure 4-5 (ABBNO, 2015). The stage gate is used to check all the inputs required for that phase are available. A review on the previous phase outputs is also performed. If any of the inputs are missing the inputs need to be collected from the customer or internal to organization before proceeding to next phase.

In this description the phase related to estimation, WBS and tendering phases were discussed in detail, whereas the in the other phases the outline of the processes are described.

4.2.1.1 Prospecting

The prospecting consists of 3 sub phases:

Market segmentation: It includes activities that help to evaluate the marketplace and identify segments of the market in which ABB want to compete. The successful, long-term development of new business depends on focusing business planning according to corporate long-term plans. These plans ensure management and marketing focus and lead discrete opportunity targeting.

Long-term positioning: This activity is cyclical in nature. Responsibility for these activities lies with management, marketing, business development and portfolio management. The main aim of this activity is to establish good relations with customer to ensure success.

Opportunity Assessment: This activity is iterative in nature. During opportunity assessment, decisions are taken about the opportunity and the ability to pursuit it. The management of top-down structure assesses the opportunity in terms of organizations mission or vision statement.

Figure 4-5 Sales / Tendering process in ABB

4.2.1.2 Opportunity Pursuit

The opportunity pursuit consist of following sub phases:

Capture team establishment: Most of the front-end planning and preparation shall be done by a core team consisting of a proposal manager, marketer, and volume leaders. Good planning and preparation is required to save money on preparation of bid and proposals.

Capture team selling: Capture team selling (CTS) is ABBs standard approach to large and complex sales scenario. Its main objectives is to match the sales team to the customer, and match the proposed value to the customer needs. Key to the success lies in the CTS methodology, simplicity and a strategic approach to sales. By introduction of CTS templates and tools, the most complex sales scenario are decoded and transformed into understandable and actionable tasks. It is a process that will encourage sales teams to fully understand the customer's priorities and enable them to propose true business improvement.

Sales Reviews: The sales review is an activity by the independent senior management. The main purposes of it is:

- Assess the probability of winning
- Assess pursuit alignment with organizational goals and strategy
- Review capture strategy and capture plans

4.2.1.3 Tender

The tender has following sub phases:

Proposal (Estimate) strategy: The proposal team needs to make initial preparations for the bid. The core teams needs to gather necessary information and then use that to develop sound proposal strategy.

Proposal (Estimate) development: The development of the proposal begins when the requisition from customer arrives. A systematic team effort based in concurrent activities ensures that the proposal is compliant, responsive, strategically sound, and consistent, and produced on time.

The proposal development contains the following activities:

- Develop draft WBS: A draft WBS and WBS dictionary need to be developed to provide the framework for controlling proposal costs, monitoring project schedule, and reporting project progress.
- Create SOW/ WBS responsibility matrix: A scope of work and WBS responsibility matrix needs be developed to ensure compatibility between technical, management, and cost volumes and to check whether all customer requirements are addressed.
- Finalize team and sub-contractor relationship: In the early phase if the contract the strategies needs to be established and legal arrangements needs to be finalized with subcontractors.
- Hold proposal kick-off meeting: A proposal kickoff meeting needs to be conducted to make assignments, convey critical program information to estimators, coordinate proposal activities, and build a cohesive team.
- Determine the design/solution freeze date: A firm and design solution date needs to be fixed to avoid endless revisions and interactions and missed deadlines of the WBS.
- Create compliance checklists: The customer’s solicitation letter needs to be analyzed and prepare a compliance checklist to develop the proposal response matrix.
- Develop proposal text and visuals: The winning probability of the proposal needs to be increase by preparing proper text and by preparing compelling visuals to sell the solution to the customer.
- Draft CTRs and cost input: The CTRs need to be prepare using the standard execution model i.e. ‘CTR module’.
- Roll up and review costing figures, defined cost drivers: Ensure CTR documents are complete and matured, a review needs to be performed on estimated costs and pricing for credibility.
- Hold status and compliance review meetings: Frequent status meetings needs to be conducted to update team members on the proposal’s status, resolve problems, and check compliance with the customer’s solicitation.

The proposal development activity inputs are:

- Instructions for budgetary offer
- Document management in sales
- Project management work Process in IMS
- Engineering work Process in IMS

- Commissioning and site activities work process in IMS
- Operations and Support
- Quality
- Sustainability (HSE, Environment, Social)
- Guideline for Risk, Contingency, Warranty and Opportunities
- Bid resources (Wizard BOM etc)
- Resource rates

The proposal development activity outputs are mostly draft proposals or documents. They are:

- Compliance response – Commercial
- Compliance response – Technical
- Bid document, including:
  - Scope description
  - Bill of material
  - Topology
  - Document list (from CTR)
  - WBS (from CTR)
  - Milestone list (from FCM)
- Full Cost Calculation Model (FCM), including:
  - Cash flow
  - Opportunity and risk register
  - Verification list
- Cost-Time-Resources (CTR), including:
  - Preliminary manning need
- Safety requirements specifications
- Procurement plan incl. Long lead item

Proposal completion:

This step is a continuation of the proposal development activity. Implement the comments from expert groups and prepare final bid documents. The activity includes, freezing solution, Finalizing WBS, releasing the scope of work, preparing responsibility matrix, program schedule and make/ buy plan etc.

Sales review (Technical / commercial))

There are several reviews needs to be performed on proposal from the customer's perspective. Need to check for last-minute problems in the proposal's focus, theme statements, writing, organization, visuals, and overall effect. In addition to this the review needs to be performed on technical solutions, system requirements, compliance, strategy, visuals, themes and space allocation.

4.2.1.4 Negotiations

This is the difficult phase after submitting the proposal. The sales managers shall develop discussion and pricing strategies to re-inforce the strengths of ABB and eliminate or mitigate the weaknesses. Above all, after submitting proposal to the customer, emphasize that this contract is more important.

Clarifications: The clarifications / negotiations phase is driven by the capture team / opportunity lead, who also shall coordinate clarification responses. Technical bid clarification meetings (BCM) shall be led by capture team / opportunity lead, with account management and bid manager to participate. If possible, ABB should take the initiative for the Minutes of Meeting, and dedicated resources must be allocated for this task. The bid team must continue its focus on gathering information and quotes from sub-suppliers.

Contract: The Risk Review database must be approved prior to contract signing. Make sure that supporting documentation is attached, and that there is consistency between supporting documentation, contract value and contract.

4.2.1.5 Close

Sales review (Lessons learned)

Reviewing the sales process and result of the tender is essential for knowledge sharing and continuous improvements. Prepare lessons learned document starting from prospecting phase to contract award phase.

The handover from sales to project is a joint process between sales and project execution. The handover is carefully planned and executed. The handover ensures good project startup and can prevent both resource issues and financial losses. The Capture team lead / Opportunity lead is responsible for initiating the handover process from the bid team to the delivery organization.

The main purpose of the handover is to transfer all knowledge about the contract and customer from one group (sales) to another (project), with communication being the key. This starts with early involvement in the sales phase from nominated project manager and other key resources (interface manager, project controller etc.), but also means that dedicated sales personnel (such as the opportunity lead) must be involved in the initial phase of the project.

The Handover Process should take place as soon as possible, at the latest one week after receipts of Purchase Order or Commercial Commitment (LOA/LOI) from Customer.

4.2.2 Estimation Model

At present ABB does not use any automatic model for estimation. ABB AS uses an excel sheet named 'CTR Module' to estimate hours required to perform any job. The Table 4-1 represents some of the fields from the CTR module. It has several fields importantly

- CTR Activity: The WBS number which will also be used in SAP to register this particular activity
- Activity Department: Concerned department for which that particular activity belongs to
- ABB procedure number: A unique identity number that can be used to represent every activity. This number is further used in WBS document for representation and description of that activity

- ABB Process step number: This field represents the process step number that is assigned in IMS is used. Generally the process referred here is Project Management process. This information provides activity belongs to which stage of the process.
- CTR Title: This is the activity name
- CTR Description: The description that activity
- Deliverables: The deliverables of particular activity
- Dependencies: The activities might be dependent on customer inputs, previous tasks, software, hardware availability, etc. All of these requirements are specified in this field.
- Hours: The number of hours required by resources in different categories (Project manager, Lead Engineer, Engineer, Document controller, Planner, etc.) are specified here.

The activities, the no of hours required by each activity goes as an input to another excel based 'Full cost module'. All the other costs related hardware, 3rd party equipment, etc. goes as input to the Full cost module to prepare a final estimation for a new project.

In general the requirements from the customer are analyzed by the experienced resources. They go through the scope, defines the activities, and also estimate the number of hours required to execute that activity. After that the estimation is reviewed by the project managers & account managers to check applicability and validity of it. Though the name is not used in ABB, It can be said that 'Expert judgement' is used for estimations. As mentioned before the expert judgment method has disadvantages like availability of experts, time needed to perform the actual estimate, etc.

CTR activity	Activity department	ABB procedure, number	ABB Process step number	CTR title, used to specify CTR output
3100	Project management	CTR 3.1	14.2 Project Start-up & execution	Establish project
3200	Project management	CTR 3.2	14.2 Project Start-up & execution	Project Execution
3210	Project management	CTR 3.3	14.2 Project Start-up & execution	Project Planning
3230	Project management	CTR 3.5	14.2 Project Start-up & execution	Purchasing planning
4210	Engineering	CTR 4.1	14.3 Design Basis review	Design Basis review
4211	Engineering	CTR 4.2	14.4 Basic Design	HW Basic Design
4215	Engineering	CTR 4.6	14.4 Basic Design	FDS Master control document
4217	Engineering	CTR 4.8	14.4 Basic Design	SCD Review. Anti-surge and Master control
4219	Engineering	CTR 4.10	14.4 Basic Design	System design 800xA and network
4222	Engineering	CTR 4.13	14.4 Basic Design	Functional Safety Assessment 1
4224	Engineering	CTR 4.15	14.4 Basic Design	Interface with Bentley Nevada supplier
5015	Engineering	CTR 5.2	14.5. Detail design and fabrication	Hardware Detail Design
5020	Engineering	CTR 5.3	14.5. Detail design and fabrication	HW FEM PSD node P57 Shutdown scope
5025	Engineering	CTR 5.4	14.5. Detail design and fabrication	HW FEM CAP node E210
5070	Engineering	CTR 5.13	14.5. Detail design and fabrication	Application & Programming for PCS Node C215
5080	Engineering	CTR 5.15	14.5. Detail design and fabrication	SW FEM PSD node P57
5085	Engineering	CTR 5.16	14.5. Detail design and fabrication	SW FEM F&G Node F14/24 - Deactivate signals
5155	Engineering	CTR 5.30	14.5. Detail design and fabrication	Hardcopy Notebook PCS node C215
5160	Engineering	CTR 5.31	14.5. Detail design and fabrication	Test report HW IAT-FAT - New FTC PCS node C64
5165	Engineering	CTR 5.32	14.5. Detail design and fabrication	Test report SW IAT-FAT - PCS Node 64
5190	Engineering	CTR 5.37	14.5. Detail design and fabrication	Anti-surge & Master control: Commissioning procedure
5250	Engineering	CTR 5.49	14.5. Detail design and fabrication	Test Report - SAT Anti-surge for new compressor Existing

6040	Engineering	CTR 6.7	14.6 Test	Integration test New connectivity servers Mirror System
6060	Engineering	CTR 6.11	14.6 Test	HW FAT - PCS Node C64 new FTC
6065	Engineering	CTR 6.12	14.6 Test	SW IAT - PCS Node C64
7100	Installation & Commissioning	CTR 7.2	14.7 Installation & commissioning	Implementation of HW FEM node P57 SD scope
7101	Installation & Commissioning	CTR 7.3	14.7 Installation & commissioning	Implementation of HW FEM ESD node E210
8100	Project management	CTR 8.5	14.8 Project Close-out and handover	Project close-out
8110	Engineering	CTR 8.6	14.8 Project Close-out and handover	As built documentation

Table 4-1 CTR Module used in ABB

4.2.3 Complexity of the project

The complexity value of all the sales opportunities is calculated in the early phase of the proposal development in ABB. The Complexity is decided by proposal owner, in close cooperation with project managers.

The project complexity value is indicative. The Opportunity Owner has the final mandate to decide how sales governance shall be applied in relation to specific proposal (estimate). However, any deviations from the standard criteria and requirements must be discussed and documented for future reference.

The project complexity calculations are partially used to segregate the project in early in the sales phase. Other than that they are not used in project phase.

The project complexity scales in ABB are shown in Table 4-2

Scale	Complexity / risk levels	Projects Criteria
Low	Low complexity / risk	value < 2MUSD (10 MNOK) and / or
		complexity points < 450
	Medium complexity / risk	value 2 – 15 MUSD, and / or
		complexity points 450 – 750
High	High complexity / Risk projects	Project value > 15 MUSD, and / or
		Complexity points > 750

Table 4-2 Project Complexity scales table

The project complexity calculation is effected by several factors in ABB. All those factors listed in Table 4-3.

SNO	Complexity factor	Description
1	Scope Of Supply	
2	The degree to which the products, by design, use new technologies or materials that are novel or unproven in service.	
3	The degree to which the integration of the products into plants or systems, even previously proven products, brings complexity in combination	Integration of ABB systems - e.g. new systems that may have impact on earlier delivered systems
4	The degree of systems engineering required to ensure our products function in combination, and the robustness and maturity of the customers systems, into which our systems and products will be integrated	Integration into the End Customer non-ABB systems, e.g. interface to 3 party systems
5	Need for project manager's understanding the customers technology (Technology=Standards and Operating practice)	If the customer requires PM to have technical competence on the delivery system "low" should not be used.
6	The degree to which the involvement of customer and/or consultant in deciding the technical requirements.	Evaluate the risk of having to spend many hours on document approvals, either due to demanding customer or to lack of competence/involvement in customer organization
7	Assessment of Delivery Time	
8	Financial & Logistical Transaction complexity	
9	Cultural Complexity	Different business cultures may also exist within Europe or even the Nordic countries
10	Requirement for Offshore/ Civil Works / Site Works	
11	Involvement of multiple ABB Units	Also consider number of interfaces, not only number of regions
12	Security Risk level countries	
13	Customer	Customers of great importance for ABB give high score, but we recommend to limit this to same risk level as RRC
14	Order Value in MUSD	
15	Impartial dispute resolution	
16	Payment Terms and Cash-flow	General evaluation of terms and cash-flow. Probability of getting payments for milestones, need for hedging (mandatory!), guarantee arrangements, are there Milestones beyond our control - e.g. As-built after completed commissioning.

Table 4-3 ABB Project complexity definition

4.3 Project Historical/ SAP data collection

ABB AS is using ERP – SAP (Enterprise resource planning software) since 2009 for different kind of internal and external applications for HR, Finance, Accounting, Projects, Production, Procurement, Sales, Services and Reporting.

SAP ERP is enterprise resource planning software developed by the German company SAP SE. Enterprise resource planning (ERP) is the integrated management of core business processes, often in real-time and mediated by software and technology. ERP provides an integrated and continuously updated view of core business processes using common databases maintained by a database management system. SAP ERP incorporates the key business functions of an organization. Business Processes included in SAP ERP include Operations (Sales & Distribution, Materials Management, Production Planning, Logistics Execution, and Quality Management), Financials (Financial Accounting, Management Accounting, and Financial Supply Chain Management) and Human Capital Management (Payroll, e-Recruiting).

Advantages of SAP ERP

- Allows easier global integration (barriers of currency exchange rates, language, and culture can be bridged automatically)
- Updates only need to be done once to be implemented company-wide
- Provides real-time information, reducing the possibility of redundancy errors
- May create a more efficient work environment for employee.
- User interface is completely customizable allowing end users to dictate the operational structure of the product

Disadvantages of SAP ERP

- Locked into relationship by contract and manageability with SAP vendor - a contract can hold a company to the vendor until it expires and it can be unprofitable to switch vendors if switching costs are too high
- Inflexibility - vendor packages may not fit a company's business model well and customization can be expensive
- Return on Investment may take too long to be profitable
- Implementations have a risk of project failure.

Employees update their personal information, record weekly hours, report travel expenses, request time off with the Employee Self Service (ESS) application in the SAP portal. Managers plan and approve compensation adjustments with the Manager Self Service (MSS) application in the SAP portal.

The employees register their hours in the SAP ESS based on the project activity number issued by the project manager on weekly basis. Once the project manager approves these hours, the data is stored in SAP database for that particular project. There are approximately 90 fields in SAP. It includes Name of employee, Personnel number, Date, Acc Assignment, Acct assignment text, General receiver, Number of hours, Measurement unit, Activity type, Absence type, Plant, Time of entry, Work center, Cost center, Network, Approved date, Approved by, etc. An extract of SAP database for a project in ABB is shown in the Figure 4-6

Each employee register their hours in different activities in the same project. So that will create a huge set of data for each project. The data from SAP database can be extracted using BW Analysis. In the SAP Business Information Warehouse (BW), BEx (Business Explorer) is the reporting tool used to work with data in the BW database. BEx has a Web-based user interface and is made up of two components, the BEx browser and the BEx analyzer. The BEx browser provides an organized interface where a user can access and work with any type of document assigned to them in the Business Information Warehouse, such as workbooks, links, and BW Web reports. The BEx analyzer allows the user to examine segmented data in a variety of useful combinations, for example when comparing financial data for different fiscal years.

ABB has approximately project historical effort data of 6 years. The size of the compressed file size is about 195 MB.

Name of emp	Persor	Date	Acct assgnmt (Re	Acct assgnt text	General receiver	Number (	Int. meas. unit	Activity Type	Att./Absence type	Network	Approval date
Employee1	101	29.02.2016	Network activity	Hardcopy Nodebook PCS node C215	N029327A1A1 4250	7,500	H	DRAW	1000	N029327A1A1	29.02.2016
Employee1	101	26.02.2016	Network activity	Hardcopy Nodebook PCS node C215	N029327A1A1 4250	7,500	H	DRAW	1000	N029327A1A1	26.02.2016
Employee1	101	25.02.2016	Network activity	Hardcopy Nodebook PCS node C215	N029327A1A1 4250	7,500	H	DRAW	1000	N029327A1A1	26.02.2016
Employee1	101	23.02.2016	Network activity	Hardcopy Nodebook PCS node C215	N029327A1A1 4250	7,500	H	DRAW	1000	N029327A1A1	26.02.2016
Employee1	101	22.02.2016	Network activity	Hardcopy Nodebook PCS node C215	N029327A1A1 4250	7,500	H	DRAW	1000	N029327A1A1	26.02.2016
Employee1	101	19.02.2016	Network activity	SW PM10 Multisystem OOC Tananger	N029327A1A1 4220	7,500	H	DRAW	1000	N029327A1A1	23.02.2016
Employee1	101	10.02.2016	Network activity	SW integration test IAT/FAT - PCS Node C	N029327A1A1 4485	7,500	H	DRAW	1000	N029327A1A1	10.02.2016
Employee1	101	09.02.2016	Network activity	SW integration test IAT/FAT - PCS Node C	N029327A1A1 4485	8	H	DRAW	1000	N029327A1A1	10.02.2016
Employee1	101	18.01.2016	Network activity	Test Spec/Report - SAT for new FTC PCS N	N029327A1A1 4365	1,500	H	DRAW	1000	N029327A1A1	28.01.2016
Employee1	101	15.01.2016	Network activity	Test Spec/Report - SAT for new FTC PCS N	N029327A1A1 4365	7,500	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	14.01.2016	Network activity	SW PM10 PCS Node C64 SD	N029327A1A1 4205	3	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	14.01.2016	Network activity	Test Spec/Report - SAT for new FTC PCS N	N029327A1A1 4365	4,500	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	13.01.2016	Network activity	SW PM10 F&G Node F14/24	N029327A1A1 4170	2	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	13.01.2016	Network activity	SW PM10 PCS Node C64 SD	N029327A1A1 4205	5,500	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	12.01.2016	Network activity	SW PM10 PCS Node C64 SD	N029327A1A1 4205	8	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	11.01.2016	Network activity	SW PM10 F&G Node F14/24	N029327A1A1 4170	4,500	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	11.01.2016	Network activity	SW PM10 for Large screen and LSD fabrica	N029327A1A1 4230	3,500	H	DRAW	1000	N029327A1A1	22.01.2016
Employee1	101	08.01.2016	Network activity	SW PM10 F&G Node F14/24	N029327A1A1 4170	4	H	DRAW	1000	N029327A1A1	13.01.2016
Employee1	101	08.01.2016	Network activity	SW PM10 PCS Node C64 SD	N029327A1A1 4205	2,500	H	DRAW	1000	N029327A1A1	13.01.2016
Employee1	101	07.01.2016	Network activity	SW PM10 F&G Node F14/24	N029327A1A1 4170	7,500	H	DRAW	1000	N029327A1A1	13.01.2016
Employee1	101	06.01.2016	Network activity	SW PM10 F&G Node F14/24	N029327A1A1 4170	8	H	DRAW	1000	N029327A1A1	13.01.2016
	101					595	H				
Employee2	861	24.03.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	2,500	H	SPEC	1030	N029327A1A1	30.03.2015
Employee2	861	23.03.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	2,500	H	SPEC	1030	N029327A1A1	30.03.2015
Employee2	861	12.03.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	8,550	H	SPEC	1030	N029327A1A1	20.03.2015
Employee2	861	11.03.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	2	H	SPEC	1030	N029327A1A1	20.03.2015
Employee2	861	05.03.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	3,500	H	SPEC	1030	N029327A1A1	13.03.2015
Employee2	861	03.03.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	1	H	SPEC	1030	N029327A1A1	13.03.2015
Employee2	861	23.02.2015	Network activity	Compliance to IEC61511	N029327A1A1 4050	2	H	SPEC	1030	N029327A1A1	06.03.2015
Employee2	861	06.02.2015	Network activity	Functional Safety Assessment 1	N029327A1A1 4070	1	H	SPEC	1030	N029327A1A1	13.02.2015
	2100					11,500	H				
Employee3	103	22.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	3	H	ENG1	1020	N029327A1A1	26.10.2015
Employee3	103	21.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	2,500	H	ENG1	1020	N029327A1A1	26.10.2015
Employee3	103	20.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	2,500	H	ENG1	1020	N029327A1A1	26.10.2015
Employee3	103	19.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	3,500	H	ENG1	1020	N029327A1A1	26.10.2015
Employee3	103	16.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	2,500	H	ENG1	1020	N029327A1A1	19.10.2015
Employee3	103	15.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	2,500	H	ENG1	1020	N029327A1A1	19.10.2015
Employee3	103	14.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	4	H	ENG1	1020	N029327A1A1	19.10.2015
Employee3	103	13.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	2,500	H	ENG1	1020	N029327A1A1	19.10.2015
Employee3	103	12.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	3,500	H	ENG1	1020	N029327A1A1	19.10.2015
Employee3	103	02.10.2015	Network activity	VOR-011 SAS Eng. Simulator befor SW FAT	N029327A1A1 4510	4	H	ENG1	1020	N029327A1A1	15.10.2015

Figure 4-6 Project historical data extract from SAP

4.4 Interview

4.4.1 Personal Interviews

P.C.Cozby (2011) mentioned that "The experience and knowledge in engineering has shown that personal interviews rather than pure questionnaires is the most effective method of knowledge acquisition which allows insight into how people categorize, organize, and use their rich experience". P.C. Cozby collected data via personal interviews which yielded data of high quality and ensured that ambiguities of the topic were resolved. Personal interviews allow the respondents to add valuable information compared to when they are requested to send the information by other means of communication.

Considering the advantages and available duration the author of the thesis has chosen to conduct the personal interviews. Table 4-4 summarizes the advantages and disadvantages of personal interviews.

Advantages	Disadvantages
• Show importance to feedback of individual participants and this may increase the likelihood of obtaining valuable contribution from them. • Allow for more in-depth data collection and comprehensive understanding. • Body language and facial expressions are more clearly identified and understood. • The interviewer can dig into explanation of responses. • Stimulus material and visual aids can be used to support the interview. • Interview length can be extended in case the participant has a greater commitment to participate and provide valuable information.	• Personal nature of respondents may lead to say things just to please the interviewer. • Requires careful planning of questions and also interviewer may require training. • Time consuming as each interview can last for 30 to 90 minutes, hence it is difficult and expensive to cover more number of participants.

Table 4-4 Advantages and Disadvantages of Personal Interview

4.4.2 Interview Questionnaire

As mentioned before, conducting interviews of experts from ABB is part of the case study for the present thesis work. The questionnaire of interviews was designed to cover the topics of historical data, sales/tendering and project management aiming at the topic of organizational performance as thesis main focus. The questionnaire is attached as 'Appendix A – Interview Questionnaire'. The entire questionnaire was framed based on the Section 2.2.4 considering four main organizational performance assessment model elements such as effectiveness, efficiency, relevance and financial viability.

The questions in the questionnaire are grouped into sections based on topics project management/ organizational performance, historical data and sales/tendering.

Section 1 of the questionnaire were designed to understand the project management and organizational process, tools, techniques, project tracking and metrics. It was assumed that most of the organizations would track the progress of the project in an orderly fashion and there were a set of metrics available for both the deliveries by the project and the process by which the deliveries are produced.

The expected outcomes from this group of questions of project management/ Organization performance are with respect to:

- The metrics used to measure the organizational /project efficiency, effectiveness and productivity.
- How the organizational processes are defined and implemented.
- How the knowledge gained during a project is transferred and applied to the subsequent projects in the organization (Lessons Learned).
- What all the feedback methodologies available for the project management to top management are.
- The project management team involvement in the sale/ tendering process (project cost estimation).
- How the project complexity metric is used during the project execution.
- The critical success factors.
- The unproductive organizational activities that are being executed in the organization.

Section 2 deals with the group of questions of sales/ tendering aiming at understanding related processes, tools, estimation processes, and measurement metrics.

The following outcomes are expected from this group of questions.

- Types of estimating techniques that are used to understand whether and how parametric models and tools were used in the estimation process.
- The information for estimators about any existing available data for future estimate as benchmarking.
- The accuracy and quality of the present estimation methods and techniques.
- The information related to the tools, organizations processes used in sales/ tendering department.
- Interviewee’s opinion about the automatic estimation tools and models.

Section 3 includes the questions of the questionnaire, which were designed to assess the understanding of usage historical data and accuracy of it.

The following outcomes are expected from this group of questions.

- Understanding of the historical data
- Any suggestions or improvements to utilize the historical data
- The accuracy of the historical data available.
- Possible means of collection of historical data.
- How the historical data is stored.

All the above discussed 3 sections are based on the subjective opinions of the project managers, In addition, several questions were aimed at general project properties. These questions are also relevant for organizational performance directly or indirectly.

4.5 Interview results

Table 4-5 presents the interview results and recommendations from the interviewees conducted at ABB as part of case study. The results are from the total of 12 interviews conducted with project managers, engineering managers and sales/tender managers in ABB. For the reader's information, all of the interviewees have more than 20 years' of experience. Table 4-5 mainly covers several topics with main focus on organizational performance and the other topics directly or indirectly associated with its improvement. Some of the results include response percentage for the individual topics.

Question topic	Interview results	Recommendations from Interviewees
Critical success factors	• Customer relations and Trust (100%). • Execution quality on budget (50%). • Innovation and new technology (40%). • Technical knowledge of engineers (60%).	• Do not provide more than what customer expects.
Project efficiency	• Measured based on the Gross margin, planned hours vs actual hours. More focus on money. Project deliveries were not measured, not thinking too much about how ABB deliver. • Too often projects are started from scratch. • More focus on internal measurements than view from customer perspective. • Most of the times proper customer design inputs is missing which is causing delays in the output. • Project KPIs are available with manual inputs. • Depends on Engineers experience. • Earned value calculations for project measurement are not used properly.	• Input quality check before start of engineering shall be performed by experienced resources to avoid unnecessary delays. • Early involvement in the projects together with customer. • Reuse the knowledge and technical solutions.
Benchmarking	• No benchmarking is used. • No visual representation to compare. Can be checked in SAP database. • Project is compared only by talking to people. • The figures in project databases i.e. SAP cannot be trusted. • No project is similar, the data cannot be compared between different customers and different platforms.	
Project management methodology	• 80% PMs felt that good process is available. • Same process for all the projects. The process is over killed for smaller projects. Smaller projects need to save time.	• Differentiation between process for smaller and bigger project is required.
Project complexity	• There is a mathematical calculation based on several factors for project complexity used by sales team. But once the sales/tender phase is finished, the complexity factor is never used in the project execution.	• Need to consider the risks and opportunities during complexity calculations

	• Some projects are not defining any project complexity. • 90% PMs felt it's not practically used by projects	• Coordination between locations and different BUs shall be considered.
Pricing model	• Fixed price is challenging and nice to work with when schedule and scope are well defined. • Fixed price: Gross margin can be improved by using efficient resources. Risk is more • Reimbursable is having less risk, low profit. More discussions about the hours and VORs which reduce efficiency of the project. • 90% of interviewees would like to work with fixed price projects. • Resource allocation is prioritized to reimbursable projects.	• The resource allocation shall be equally prioritized between fixed price and Reimbursable. • Project scope shall be monitored effectively. Avoid scope creeps.
Sales team & Project management	• Project management team's involvement in sales/ tender process is good in some locations. Needs improvement in other locations. • 80% PMs mentioned that participation is helpful and felt that lot of uncertainties can be avoided, whereas the rest 20% felt that participation is required for the Lead engineers. • 100% PMs felt that workload is increasing. • 100% interviewees felt that it's crucial to involve both PM and technical resource in the sale/bid process for efficient estimations. • Sales and Account management lack structured statistics and information for effective contract and frame agreement negotiations.	• A quality handover is required by sales team to project management team for execution.
Lessons learned	• PMs said Synergies are collected, but they have not been followed up quite good or left as they are (70%). • Lessons learned is mostly person dependent. Need to know the people and talk to them to find out what has happened. • PMs said Lessons learned is captured in closeout report in the project. But they are not sure if anybody has looked and analyzed it at later stage. It is not possible to search for lessons learned until one knows the project number (90%)	• Narrow things down to easily be searchable, accessible and readable format for lessons learned, instead of writing big reports.
Unproductive activities	• Too much internal reporting burden on PMs as they have to enter the same information in several places manually every week. 100% PMs felt that it's creating double work, they could not be able to see the value addition. • Project status cannot be located in a single website. It's been divided into, SAP, Plan, KPI's, SharePoint etc., But they don't provide project overall status at one place.	• Rebuild the entire system starting from scratch. Only one system for everything.
Tools and Processes	• 100% PMs felt that there are too many tools. Systems are very heavy. There is no place to see everything at once place. Sometimes it's creating more administration burden.	• Good courses and training are required, Need to have proper feedback routines.

	• Organization is trying to simplify the systems and processes, but sometimes it is creating negative effects. • Tools and processes are deployed without any testing. No proper feedback mechanism is in place for those.	• Take baby steps when deploying new processes or tools. • Introduce rollups when it is necessary
KPI	• Only customer KPI's are available. • No dashboards exists for the project status. (100%) • Saffron level 5 plan can provide some details, but it is time taking and it is not applicable for smaller projects. • There are some KPIs available but not understood by everybody.	• Project status dashboard shall be established with earned value calculations
Estimation accuracy	• Estimation varies a lot and depends on the resources estimating it, but most of the time it is accurate (60%) • Depends on scope changes customer (50%). • Requires a feedback loop • Complexity is not defined well and not considered during estimate. • Sales team and execution are separate boats. • Too much optimistic approach.	• Work close together with the customers from FEED phase of the project.
Estimation method	• Manual method is used. Experts are estimating the effort required (100%). • Estimator needs to understand creating WBS is not doing engineering.	• Need to reduce time used for Sales/ tender estimations. • Do not dig so much technical details during bidding phase.
Automatic tools using historical data	• Can be used but the jobs we are getting are different every time. • Cannot be trusted. • Difficult to Standardize. Several variables are involved. • Very diverse project portfolios exist. Can be used in preliminary phase of projects.	
Historical data	• SAP tools are very difficult. Manual comparison is time taking (90%). • Not sure of usage due to very small projects. • Difficult to fetch it from SAP when it is necessary. The super users are busy with other activities to get help from.	• Reduce no of activities to make it standardize. • Standardize the deliverables and change it according to complexity.
Accuracy of Historical data	• Not very accurate as the project needs to make some adjustments. • Assign this responsibility to engineers.	• Stress on registering hours on proper activity. • Management focus is required.
Others	• Communication between internal organizations is not up to mark.	• Consider human factors thinking to understand the customer better.

Table 4-5 Interview Results

5 Results Discussion and Recommendations

The chapter discusses the results from the interviews and case study in ABB by using the developed models described in chapter 3. The selected phases of the models are validated and discussed against data from the interviews and case study. It also includes validation of models. Based on the results from present work, the improvements and recommendations proposed for organizational performance are discussed.

5.1 Improvements in Estimation process

The present section deals with estimation process for better utilization of historical data for organizational performance. The process yields reduction of about 10 to 15% of the time required for future estimates. This is performed by applying the developed model presented in Section 0 by applying the data obtained from interviews and study of the tools, processes at ABB.

As was mentioned before, the phases of the developed models include A - Collection of Inputs, B - Estimation model, C - Adjustment process (Expert Judgement), D - Project full cost and contingencies, E - Re Estimation and F - Estimation process improvements. The result of these phases have been discussed here against the estimation practices in ABB.

The case study and the interview results show the process of estimation pattern

- The cost estimation and activity definition are done too early in the bidding process and is usually based on incomplete specifications.
- The estimation is based on single person's judgment. Once it is established, it is difficult to change it.
- There is no availability of historical data on which the estimates are based for the new projects.
- Full lifecycle of the project is effectively handled by very less number of resources due to various reasons.

A: Results for Collection of Estimation Inputs

Project requirements related: The project requirement documents are crucial for the project estimation. When it comes to ABB, the requirement documents are not in its control as these are issued by customer to ABB. At the same time the quality of these documents are uncertain until ABB receives them. According to the interview results ABB's critical success factor is the customer trust. This means that ABB already has decent relations with them. ABB needs to use this opportunity to offer its 'early involvement into the projects' to the customers for preparing the requirement documents in order to mitigate the uncertainty in them. This step could increase the efficiency of the customer as it could reduce time required for the customer to prepare these documents. Accordingly the quality of these documents can also increase. So that ABB can provide better estimate to customers. In summary it can be recommended that early involvement of suppliers into the projects increases the customer efficiency

Processes related: As discussed earlier ABB uses IMS for the project management, engineering process and sale processes. These 3 processes are the important inputs to the 'estimation process' as these processes decide how the execution of the required task is performed. The processes have direct relation with the number of hours required to execute the projects. As per the interview results these processes are overkilled for different size and duration of the project. So here it is important to consider the size and duration of the project when selecting processes. In addition it is also important to define the phases of the processes that can be taken out for smaller projects (Consider the standards) for reducing the cost to the customers as well.

From the interview results, it is also observed that the new tools and processes are launched without proper introduction or training in ABB. When there are so many tools and processes deployed frequently, employees get a sort of feeling of stress that 'one more new tool is to be learned'. The tools and processes needs to be prepared, planned and deployed from the very beginning, so that it won't become a chaotic scramble at the end. For instance by using a minimally disruptive approach, such as a pilot program or a phased implementation. When a new tool is launched generally there will be temporary enthusiasm in employees to learn, but gradually they feel it as a burden. Hence, ABB needs to optimize and test the tools or processes in advance before deploying to utilize them to maximum extent.

The present work suggests that ABB need to carry out the following things in order optimize tools and processes:

1. Collect all the tools within ABB
2. Collect all the processes within ABB
3. Evaluate them for which purpose tools and processes are used.
4. Assess the redundant functionalities, redundant processes old tools, not applicable, processes
5. Check if those functionalities can be achieved in one tool or one process.
6. Test that process or tool in 2 to 3 pilot project.
7. Make any adjustments if required, and deploy the process in the entire organization
8. Scrap the old tools and processes.

B: Results for Estimation Model

From the interview results and experience in ABB, the author realizes that no estimation model exists in ABB for the use. But, as explained before, ABB uses an excel sheet called 'CTR Module' for estimating activities.

The author has verified activities of estimation in the CTR module for 5 projects belong to Green field and Brown field. According to the observations

- The activities are decomposed based on work that has to be performed, but not based on the deliverables. When the sales department hands over project to the project department, activities become difficult to understand by the project team. Project team needs to spend more time to understand and perform the activities. There are some agreements between the sales people and the customer regarding the deliveries which might have lost during this period of transitions.
- There are no common activities between the technical activities. Each project has defined the activities and each of them is different. It makes complex to compare the project with

another project. So comparison of estimation could be difficult. A reference to one project to another cannot be established.

- The project management activities are similar in all projects.
- Some activities are defined with very few hours. This makes the administration more difficult to follow-up those activities
- In some projects it happens that there are no descriptions and deliveries mentioned by ABB for the activities. In this case deliveries have to be according to customer demands.
- The activities in the CTR module and the 'project activities' that are registered in SAP are not similar. Sometimes 3 to 4 activities in CTR module are grouped and created as a single project activity in SAP. This makes difficult to compare the actual estimation versus consumed hours. So at the end project needs to depend on total number of hours consumed rather than hours of individual activities.

PMBOK (2008) defined in the context of the WBS, work refers to work products or deliverables that are the result of activity and not to the activity itself.

If the estimator attempts to capture any action-oriented details in the WBS, then he will likely include either too many actions or too few actions. Too many actions will exceed 100% of the required scope and too few will fall short of 100% of the required scope. The best way to adhere to the 100% rule is to define WBS elements in terms of outcomes or results, not actions. When a project provides professional services, a common technique is to capture all planned deliverables to create a deliverable-oriented WBS. Work breakdown structures that subdivide work by project phases (e.g. preliminary design phase, critical design phase) must ensure that phases are clearly separated by deliverables (Gregory T, 2001).

A work package at the activity level is a task that:

- Can be realistically and confidently estimated
- Makes no sense practically to break down any further
- Produces a deliverable which is measurable
- Forms a unique package of work which can be outsourced or contracted out.

Based on this ABB needs to decompose the activities in a different way than today. ABB is product and service based company. For the Products (Standard hardware & Software) ABB has a very good Supply Chain management system which is having good control over estimation, order and deliveries. In Oil & Gas industry the most of the engineering services (about 90%) are delivered as documents. There may be some deviations for this when it comes to delivery of control software etc. When it comes to the ABB, during the estimation phase it needs to decompose the service activities based on documents as shown in Table 5-1. So that it will be easier to standardize WBS activities between projects.

During the handover phase from sales team to project team, the same activities from CTR module have to be registered in the SAP for project follow-up and time sheet registration. At the end of the project there will be two databases one is estimated hours and another is an extract of consumed hours from SAP. Accordingly, as the activities are similar the databases are comparable to find out if more or less hours consumed for making one particular document.

However, some documents requires very few hours to complete. As discussed creating several activities with very few hours can make administration burden. A single activity can be created by grouping these documents together to avoid creating lot of activities. For example the hardware cabinet drawings for several cabinets can be grouped as one activity as suggested in Table 5-1.

CTR activity	Activity department	ABB procedure, number	Client specific classification # 2	CTR title, Document
3200	Project management	CTR 3.2	14.2 Project Start-up & execution	Project Quality& Safety plan
3210	Project management	CTR 3.3	14.2 Project Start-up & execution	Project Plan
3230	Project management	CTR 3.5	14.2 Project Start-up & execution	Purchasing plan
4210	Engineering	CTR 4.1	14.3 Design Basis review	Design Basis review Check lists (10)
4211	Engineering	CTR 4.2	14.4 Basic Design	HW - Loop Typical Docs (12)
4213	Engineering	CTR 4.4	14.4 Basic Design	HW - Cabinet drawings Docs (12)
4215	Engineering	CTR 4.6	14.4 Basic Design	FDS Master control document
4217	Engineering	CTR 4.8	14.4 Basic Design	SCD Review checklists
4219	Engineering	CTR 4.10	14.4 Basic Design	System Configuration document
5015	Engineering	CTR 5.2	14.5. Detail design and fabrication	Hardware work package Node P57
5020	Engineering	CTR 5.3	14.5. Detail design and fabrication	Hardware work package Node E210
5025	Engineering	CTR 5.4	14.5. Detail design and fabrication	HW FEM CAP node E210
5070	Engineering	CTR 5.13	14.5. Detail design and fabrication	SW code document for PCS Node C215
5075	Engineering	CTR 5.14	14.5. Detail design and fabrication	SW code document for PCS Node C64
5160	Engineering	CTR 5.31	14.5. Detail design and fabrication	Test Specification PCS node C64
5165	Engineering	CTR 5.32	14.5. Detail design and fabrication	Test Specification PCS Node 64
5190	Engineering	CTR 5.37	14.5. Detail design and fabrication	Commissioning procedure
5250	Engineering	CTR 5.49	14.6 Test	Test report PCS node C64
6010	Engineering	CTR 6.1	14.6 Test	Test report PCS Node 64
7100	Installation & Commissioning	CTR 7.2	14.7 Installation & commissioning	HW work pack signed P57 SD scope
8100	Project management	CTR 8.5	14.8 Project Close-out	Project close-out report
8110	Engineering	CTR 8.6	14.8 Project Close-out	As built documentation

Table 5-1 Activity decomposition based on documents

The next step is to create a parametric model after adjusting the way activities are decomposed as suggested in Table 5-1. The parametric model has to be developed based on the below equation 5-1 suggested by the author. The equation was derived based on equation 2-1 given in Section 2.4.4.5.

$$\hat{E} = Ae * PC * SR \qquad (5\text{-}1)$$

$\hat{E}$ = *design effort,*
Ae = Aggregated effort for an activity,
PC = project complexity,
SR = severity of requirements

The design effort value in above equation is applicable for a single activity. Based on this equation 5-1 for 'N' number of activities the total design effort $\hat{E}(N)$ can be defined as

$$\hat{E}(N) = Ae * PC * SR * N \qquad (5\text{-}2)$$

The model includes 2 key independent variables project complexity and severity of requirements. These variables can be adjusted to the requirements of the company based on the equation 2-1 suggested by Hamdi & Vince (2001) and on several factors discussed earlier in the model. For the present case study in ABB, the equation was simplified by neglecting the constants. The simplified formula forms a simple nonlinear regression model.

As seen in Equation 5-3 the design effort ($\hat{E}$) in the model is obtained by multiplying the aggregate effort (*Ae*) for an activity with Project complexity (*PC*) and severity of requirements (*SR*). The aggregate effort for each activity is the value from the estimate database created based on the historical data which is discussed in subsequent chapter. As per the above suggestion each activity has to be defined as a document with aggregated effort value. But the values for each document might be approximate value during the initial phase of the model development. This is because of an exact value has to be derived by aggregating the values of historical data of several projects and this value can be used as the reference value in the model.

The key variable 'project complexity (*PC*)' in the model equation is one of the measurement for performance indication. By defining the project complexity early in the estimation phase, lot of issues in the project phase will be minimized.

To author's understanding ABB has a good way of analyzing the project complexity and risk during the sales/tender phase of the project. But the usage of the complexity and risk values during the project execution is unknown. One more surprising fact is that the most of the project managers do not bother about this values once the project handed over from sales department to project department. The project complexity calculation in ABB is based on several factors explained in Section 4.2.3. This calculation includes most of the factors suggested in project complexity model from Section 2.5.2.1. But it is missing two factors: one is resource team members' average years of experience and the other is the pricing model which includes the fixed or reimbursable price. These two factors are more important factors when selecting the project complexity. The project complexity thinking can be applied based on methodology given in Section 2.5.2.3. Applying this can increase organizational performance.

The author suggests that project complexity can be classified as shown in Table 5-3 in accordance with the standard AACE (2016). It is also suggested that he project complexity is divided into 5 classes based on maturity level of project definition deliverables and also the other factors defined in the in Section 4.2.3. The standard AACE (2016) proposed a classification table (See Table 5-2) named as 'cost estimation classification matrix for EPC's in process industries' which is based on project complexity. Further, they have defined different accuracy ranges of the cost estimation based on project complexity. The accuracy ranges are used as reference in this thesis as project complexity factor.

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Table 5-2 Cost estimate classification matrix for Process Industries

Project complexity class	Accuracy Low range (In Negative)	Accuracy High Range	Accuracy Median	PC value
PC class5	50	100	75	1,75
PC class4	30	50	40	1,40
PC class3	20	30	25	1,25
PC class2	15	20	17	1,17
PC class1	10	15	12	1,12

Table 5-3 PC value for different classes

The key variable 'Severity of requirements *(SR*)' in the model equation based on the customer behavior and classified based on Table 5-4.

- When the customer known to ABB provides *good requirements*, SR class1 can be selected.
- When the customer known to ABB provides *average requirements*, SR class2 can be selected.
- When the customer is *new* to ABB, also SR class2 can be selected.
- When the customer known to ABB or new but the *requirements are very poor* SR class3 can be selected.

SR Class	SR value	Design requirements
SR class1	1	No too difficult to meet
SR class2	1,5	Difficult to meet
SR class3	2	Extremely difficult meet

Table 5-4 SR value and Classes

Here an example calculations were performed for design effort values based on equation 5-2. Project complexity is assumed as PC class3 whereas severity requirement is assumed as SR class2. Accordingly equation 5-2 becomes as given by

$$\hat{E}(N) = Ae * 1{,}25 * 1{,}5 * N \qquad 5\text{-}4$$

Some of the activities listed in Table 5-5 were selected from Table 5-1 for assessing how the estimation model works for design effort calculations. For the calculations, other variables aggregated effort (Ae) and number of documents (N) in equation 5-4 were assumed as listed in Table 5-5 for the selected activities. The predicted results for design effort $\hat{E}(N)$ were listed in Table 5-5.

CTR activity	Activity department	ABB procedure, number	CTR title, Document	No Of docs (N)	Aggregated effort(Ae)	Design effort ($\hat{E}(N)$)
3210	Project management	CTR 3.3	Project Plan	1	55	103
3230	Project management	CTR 3.5	Purchasing plan	1	60	113
4210	Engineering	CTR 4.1	Design Basis review Check lists (10)	10	2	38
4211	Engineering	CTR 4.2	HW - Loop Typicals Docs (12)	12	10	225
4213	Engineering	CTR 4.4	HW - Cabinet drawings Docs (12)	12	10	225
4215	Engineering	CTR 4.6	FDS Master control document	2	50	188
4219	Engineering	CTR 4.10	System Configuration document	5	40	375
5015	Engineering	CTR 5.2	Hardware workpackage Node P57	1	30	56
5025	Engineering	CTR 5.4	HW FEM CAP node E210	1	60	113
5070	Engineering	CTR 5.13	SW code document for PCS Node C215	1	70	131
5075	Engineering	CTR 5.14	SW code document for PCS Node C64	1	25	47
5160	Engineering	CTR 5.31	Test Specification PCS node C64	1	45	84
5190	Engineering	CTR 5.37	Commissioning procedure	2	35	131
5250	Engineering	CTR 5.49	Test report PCS node C64	1	45	84
7100	Installation & Commissioning	CTR 7.2	HW workpack signed P57 SD scope	1	50	94
8100	Project management	CTR 8.5	Project close-out report	1	55	103
8110	Engineering	CTR 8.6	As built documentation	50	3	281

Table 5-5 Example for Design effort calculation using formula

So far complexity has been discussed in terms of factors defined in Section 4.2.3 which can be treated as a static evaluation during estimation phase. But complexity assessment is dynamic process and it should be reviewed and updated every time key changes take place. The important key changes are major changes in scope, resources, technology and changes in corporate strategy.

ABB is a technology based company. Most of the times the issues might arise because of the technical difficulties than the general project management issues. Every project is driven by its own attributes of technical complexity, such as safety requirements, security requirements, stability of hardware, and software, controller load, project team experience, and level of technology integration. So it is a good idea to separate the technical items from the complexity model defined in Section 2.5.2.1 and establish a separate technical complexity model including these technical items. This model can be used to verify and decide the technical complexity of the project. Understanding technical complexities helps in assembling the right sponsors, project manager and team, as well as the inherent technical risks.

In summary the following recommendations are made for estimation model.

- The service activities needs to be decomposed based on documents for easier standardization of WBS activities and for benchmarking for future projects.
- The same activities from CTR module have to be registered in the SAP for project follow-up and time sheet registration, as the activities and their databases are comparable.
- The parametric model has to be established and used for design effort estimation.
- The project complexity is suggested to be classified and its thinking can be applied in the estimation model to provide efficient estimations.
- Complexity assessment is dynamic process and it should be reviewed and updated every time key changes take place.
- Technical items needs to be separated from the complexity model and a separate technical complexity model (incorporating technical items) need to be established to avoid technical risks.

C: Results for Adjustment Process (Expert Judgment):

Any organization cannot 100% depend on the parametric model alone. Though the parametric estimation models considers the key variables project complexity, severity requirements, etc. the output produced by them need to be verified manually again for possible errors. The adjustment process makes sure that any errors or mistakes caused by the model are corrected and improved.

From the interview results most of the interviewees expressed concerns about automatic tools based on parametric models. Here the author suggests that applying adjustment process can reduce concerns and help to obtain improved level of confidence on the estimation produced. Further, its application reduces the time required for the entire estimation process through manual verification of model predictions.

D: Results for Project Full Cost & Contingencies

When calculating project full cost it is important the Sales/tendering team have good communication with all the BUs that need to be involved in the project. According to author's understanding the inputs to full cost module tools need to be collected manually in ABB. This is time taking process and also the estimator who is finalizing the bid needs to wait until he gets the input from all the BUs involved. When one of the BUs gets delayed in providing the input, the estimator cannot produce the full cost within schedule. Further when there are any changes in the BU's estimation, the entire full cost needs to be updated again. So the author suggests that ABB needs to establish a single tool for entire estimate process. All disciplines within ABB shall have the same understanding of its delivery to the customers.

Sometime business objectives, customers, policies force to select a budget far less or more than the estimated. In this case an engineering estimate shall be prepared based on the suggested estimation process. But a separate 'business estimate' can be used for actual full cost after implementing the engineering estimate.

F: Results for Estimation process improvements

The estimation processes or models are improved when the data from completed project is collected properly and it is reliable. Maintaining an ongoing "consumed hours" database of the recorded time spent on each activity of the projects is essential. This data helps to estimate future projects and identify the historically accurate buffer time needed to realistically perform the work.

By using the developed estimation model with feedback loop in ABB and implementing the above suggested measures, the following things can be achieved.

- A project completion actual estimates, re-estimate, VORs can be compared and quality of estimation process can be assessed.
- The historical data from project can be fed back to the estimation model and process.
- The estimators can have benchmarking data.

5.1.1 Commercial software

Putting a historical database system in place and setting up estimation models requires many hours of concentrated effort and process changes. Asking internal company resources to provide dedicated time and effort is typically impractical as they lack experience in this field. It can be recommended that organizations can consider hiring special consultants who can do the job more quickly and efficiently. Other option is selecting the commercial software available in the market and providing staff training. The advantages of commercial software are to:

- Improve productivity: Save time by using simulations to quickly and automatically model and visualize thousands of “what if” scenarios.
- Enhance quality: Meet quality objectives by using simulation results and capability metrics to determine optimal product specifications.
- Increase revenue: Maximize growth while optimizing organization’s ability to react effectively to market disruptions and random events.
- Decrease costs: Generate sensitivity charts that identify which variables have the biggest impact on the costs.
- Communicate: Share the findings through graphs, charts, and reports that can lead to present and communicate the results of the analyses.
- Collaborate: Work as a team, sharing models and data to get work done faster.

Some of the best commercial software products available for project estimation utilizing the historical data are:

@Risk from Palisade Corporation: @Risk is an add-in to Microsoft Excel. This software performs risk analysis using Monte Carlo simulation. The range of possible outcomes and the likelihood that each result will occur are shown in Microsoft Excel spreadsheet. This can help decision makers to make decisions under uncertainties. In oil and gas industry, some of its application are in exploration and production, oil reserves estimation, project estimation, pricing, and regulation compliance. When setting up the model, the user can select the probability distribution or define the distribution from the historical data for a given input. The results from the simulation are the whole range of possible outcomes with the probabilities that occur. It also offers the tornado chart and sensitivity analysis to identify the critical success factors. Business decisions, technical decisions and scientific decisions use estimates and assumptions. With @RISK, users can explicitly include the uncertainty present in the estimates to generate results that show all possible outcomes (Palisade, 2016).

Crystal Ball from Oracle: Crystal Ball is a spreadsheet-based application which is suitable for predictive modelling, forecasting, simulation and optimization. Similar to @Risk it is also Monte Carlo software. It uses Monte Carlo simulation to calculate and record the results of thousands of different scenarios. Analysis of these cases reveals the range of possible outcome, their probability to occur, the variable that mostly impact the model and the key point that should be focused on (Oracle, 2016).

Sage Estimating by EOS group: Sage Estimating provides a smarter, automated way to project estimate. By eliminating redundant data-entry and error-prone processes, Sage Estimating helps projects to run efficiently from initial estimate to project completion. Further, sage Estimating eliminates the drudgery associated with complex calculations and manual, repetitive, and routine estimating tasks. The intuitive interface with familiar bid worksheets make building estimates easy. The software allows executing processes, pricing items, querying data, and taking off a project with ease and speed (EOSgroup, 2016).

5.2 Improvements in Lessons Learned

The present section deals with lessons learned process for organization performance by applying the developed model presented in Section 3.2. As was mentioned before, the phases of the models include A - Establish infrastructure, B - Communicate and Deploy, C - Capture Lessons, D- Sanity Check, E- Incorporate Lessons into processes and F- Rollout enriched process. These phases have been discussed against performance of ABB, as part of case study. The following results and improvements can be observed based on application of the model for organizational performance.

A: Establish Infrastructure: According to interview results from the case study, it is known that lessons learned documents for every project in ABB are stored in the electronic document management system (EDMS). In general, the identity number for lessons learned document is defined based on the project specification requirements. In other words, the document identity is not similar for all the projects. Until and unless the identity number is known, lessons learned document cannot be explored easily. At the same time, the EDMS access for a particular project is restricted to fewer people in the organization. This makes search, navigation and retrieve capabilities of EDMS challenging. It is also observed that the documents are not distributed after they have been created. Over the time, this causes to forget the project and loose the lessons learned.

The lessons learned documents from all the projects can be extracted and complied to form a separate document. But it is time taking process and somebody having good experience needs to focus on it. As most of the times the resources are busy in project activities, very less attention is paid in that direction.

Upon looking at all these difficulties, it is not advisable to use EDMS as storage location of lessons learned document. At the same time, it is in fact not advisable to store lessons learned as a document itself.

For capturing lessons throughout the project life cycle and to be easily accessible there shall be a proper system other than EDMS. ABB has already IMS system available which is more interactive. It can be suggested that ABB can create separate lessons learned webpage (share point site with metadata) in IMS where all the lessons learned can be registered.

The current author further suggests that the following parameters should be registered in the webpage for each and every lessons learned case, so that these parameters can be used to search or sort out from the web interface.

- Project name
- Project type
- Project phase
- Project environment
- Functional discipline
- System(800xA, Advant, Electrical, Marine)
- Technical / Commercial
- Issue / problem / Case
- Resolution / Solution
- Context and key words
- Scenario, if applicable

B: Results for Communicate and Apply: Even though ABB is trying to send the information to everybody, sometimes it is not passing onto all the employees. The intensity and management focus is not reaching out to every individual. ABB has any way very good communication interfaces like mail, SharePoint sites, skype for business, yammer groups. So it has much better communication channels compared to previous years. As suggested earlier offering some kind of gifts for innovative cases and solutions can improve the interest on lessons learned activities among the employees.

C: Results for Capture Lessons: The process steps in IMS for project management process define lessons learned in the project closeout phase. As mentioned before, current lessons-learned practices are inadequate. Where these practices are in place in organizations, they are usually achieved through ‘end-of-project reviews’. The End-of-project reviews are often simple recording of experiences (Pinto 1999). Nevertheless it is questionable how many people normally remember what happened 3months, 6months or 1 year back without documenting lessons learned. People tend to forget things very fast. Further the project team members do not have time to review lessons learnt as they are reassigned almost immediately to new projects before they even have time to perform post-project reviews. This means that project failures and successes are rarely analyzed and learning just does not happen. Hence lessons from failed projects are quickly swept aside, with little effort expended on trying to discover useful lessons that can be carried over to future efforts. It is therefore necessary to capture positive and negative things that happened regularly, while project is ongoing. As suggested before, lessons learned should be documented throughout the project. In other words, the process shall be adjusted such that the lessons learned are captured throughout the project life cycle. At the end of the project all these lessons learned shall be compiled to make it as a report and distributed among the project teams.

Most of the times the lessons learned are focusing on commercial issues rather than technical issues. It might be because of the lessons learned is project managers' responsibility. The project managers mostly concentrate on commercial activities and issues, the technical issues might be passed on to the engineering groups. So even though the issue is solved with good results it might not have been documented to refer it at the end of the project. So organizations need to encourage experts and other engineers on this issue. Possibly it can be assigned as target in their performance appraisals.

D: Results for Sanity Check: Lessons learned captured for any project shall be reviewed at the end of the project, so that we can keep the lessons learned repository clean. A dedicated resource for this activity for all functions shall be assigned, so that they have a better control. While performing sanity check the following things shall be considered.

- Fully capture the essence of the discussion and finalize a formal lessons learned document
- Validate lessons learned, seek clarification when/where necessary
- Summarize lessons learned and provide teams with a summary check.

E: Results for 'Incorporate Lessons into Process': According to interview and discussion once the lessons learned document is formed it is stored in EDMS and but not used any further. This is where ABB needs more focus on. ABB needs to verify each and every lessons learned case and make required changes in the processes, tools and technical requirements. This process improves the quality of execution and so that similar mistakes will not be repeated. Once a technical or commercial problem is solved, there is no need to reinvent the wheel to solve the problem again and again. So organizations processes shall make sure that they are improved such that mistakes are not repeated again.

When such a lessons learned process is implemented the learning capabilities of employees would enable to apply their experiences across different projects thereby improving their project and organizational performances by reducing time required to solve issues. Further it enables optimized value generation for customer and their plants.

5.3 Improvements in Historical data utilization

The present section deals with historical data utilization for increasing organization performance. The data can be utilized for several purposes as stated in Section 0. This section explains how this data can be utilized for the project estimation process by applying the developed model presented in Section 3.3.

According to the case study it is observed that ABB is not using any historical data utilization process model so far. However, ABB is making necessary plans to make use of the historical data for resource forecasting, budgeting, etc. Existing tools like SAP, SharePoint have different functionalities like Dashboards, Reporting and Agile visualization and the usage of these tools is not so easy and very few people in the organization are aware of these functionalities. Therefore, it is necessary to establish historical data utilization model suggested in Section 3.3 to avoid this manual efforts and achieve suitable solutions. Figure 5-1 illustrates a suggested historical data utilization model specific to ABB.

A: Data Understanding & B: Data Preparation: The author collected project estimation databases and historical data of 5 Green field and Brown field projects in ABB to perform 'Data Understanding' and 'Data Preparation' activities from the model. The historical data from SAP has been manually retrieved and then verified for the use. It can be also performed by SAP BW analysis automatic tool. After verifying the activities for each project, the author came to conclusion that most of the projects are different and each project contains dissimilar activities. Further the activities defined in estimation database and activities defined in the project SAP database are not similar, making it difficult to compare both these, to realize how many hours estimated each activity and how many consumed. It is a lot of effort required to do this job for each and every project manually. The most difficult task when examining historical data is not the process of examining itself. But it is rather the process of gathering and more importantly interpreting the data. It means having the clean historical data is one hurdle and using it further is another hurdle. Hence organizations needs to ask themselves the following questions for checking the data quality.

- Do we really have all the data we need to make an informed decision?
- Do we understand what the data really mean?
- Can we trust the data in making this decision?
- When do we trust the data? Is this data justified?

The interview results and case study also confirmed that reliability of the historical data is not accurate. This is due to several reasons.

- Project managers do not have much control over which activity (WBS) the employees are filling their hours on.
- Some of the projects are so small that it is difficult to follow up.
- The work load of the employees.
- There may be cases that employees are booking the hours on different activities than they are supposed to.

In this case it is difficult to believe that the project effort historical data is correct. As Redman (2015) stated, it is time for managers to recognize that doing their best in light of poor data is no longer acceptable. He further says that decision making and utilization is just so much more effective when one has a complete, trusted, fully-understood data.

Hence the first step to utilize the historical data is to be able to get trusted it by the management focus. The entire organization needs to understand that driving data quality across whole organization requires top-down leadership and managers at all levels.

To achieve this the WBS activities shall define different way, so that it will be easier to relate them at the end of the project or during the project. This is applicable even if organization chooses to do the comparison manually or using an automatic model. Although projects are unique the deliveries might be of similar type. So the activities must be defined as document deliveries as suggested in Section 5.1. Then the historical data is cleaner and can become comparable between projects.

C: Models: The historical data utilization models can make better understanding of cause and effect relationship across a number of variables in the historical data repository. It can figure out which relationship contributes the most to achieve defined goals.

In ABB the historical process model can be used to calculate the aggregated effort value for each activity. At the end of any project exact design effort data is available in SAP database. This is exactly how many hours took to complete that activity derived from the project. Here the consumed design effort at project end is referred as '*Ê(N) P1end*'. Using this the aggregated effort of an activity at end of project1 (P1) is derived based on equation 5-2:

$$Ae\ P1 = \hat{E}(N)\ P1end / PC*SR*N \qquad 5\text{-}5$$

Where,

PC = Project complexity - Already known value from estimation
SR = Severity of requirements - Already known value from estimation
N = Document number - Might have been changed during the project

So an aggregated effort value (Unit value) for one activity can be achieved by aggregating the value from 'n' number of projects as defined below

$$Ae\ (u) = AeP1+Aep2+AeP3+.....+AePn / n \qquad 5\text{-}6$$

These aggregated effort values and the process can be used in ABB for following purposes

- Aggregates effort values of Unit cost for activities
- Forecasting, Benchmarking by estimator and project managers
- Can be used to analyze their Contract , Contract rates and Frame agreements
- For creating Dashboards
- For checking Occupation ratio of employees

As explained in the cone of uncertainty in Section 2.4.2, when several projects are aggregated the unit value becomes more certain for all the projects.

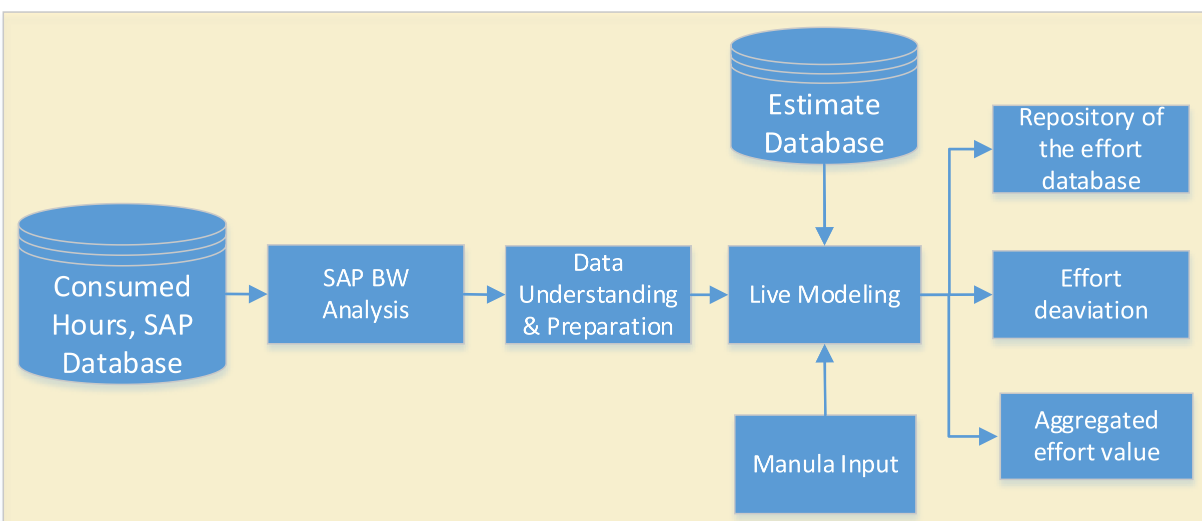

Figure 5-1 Historical data utilization process for ABB

The historical process model shall be able to segregate the aggregated value of project effort for each activity based on Discipline, Department, Customer, Green field/Brown field, System, Onshore/Offshore, Project size and Complexity etc. This value can be utilized by the estimator for future estimation and benchmarking. The models need to verified and adjusted according to quality measurements and market outlook frequently.

The evaluation and deployment process of the historical data utilization model follow similar way as explained in estimation process deployment in section 5.1.

5.3.1 Commercial Software

Most companies today do not have the expertise in-house to either develop or implement a historical database system, and it would take significant time and effort to develop the necessary skills. Instead, many companies are opting to hire professional consultants who specialize in providing these types of services.

EOS Advisor: Eos Advisor is a web-based project history and benchmarking solution built for the preconstruction and design-built markets. It is a quick and easy way to access the company’s historical cost data to establish conceptual or feasible estimates and benchmarking studies. Advisor allows estimators, project managers, and business development staff to quickly search past budgets and adjust current projects for inflation, job size, and location. Advisor also supports the benchmarking process so they can make better decisions and reduce risks.

EOS Project Analytics: This module brings customizable dashboard-style reporting, multiple element metrics, ratio charts, and currency conversion capabilities to Eos Advisor. Organizations enjoys the ability to create and render custom project portfolios in a Microsoft Excel application. Users can easily compare, analyze, and manipulate their historical project data.

5.4 Improvements in KPIs

After analyzing the existing KPIs in ABB and also considering the opinions from the interviewees, the authors acknowledged that ABB has very well defined KPIs. The KPIs cover the most performance objective factors like cost, quality, speed, dependability and flexibility as defined in Section 2.2.1.

The Relex dashboard (see section 0) defined by ABB covers all the necessary organizational performance indicators. But according to the author’s observation and interview results from case study in ABB, most of the data to KPIs is manually collected. When any data is collected manually the reliability of the data is uncertain. The data can be manipulated to achieve the required KPI numbers. Therefore, the author suggests that data for those KPIs has to be obtained from project historical data, and tools or any other relevant sources. One more observation is that most of the employees think that the KPIs are defined for only managers. At the same time many people either do not understand what KPIs are meant for. In general the KPIs are defined targeting entire organization roles. Indeed it is significant for all the employees in organization to understand the organizational strategy, business goals and organizational performance factors and to work towards achieving these. ABB needs to encourage all the employees to follow these KPIs and contribute towards them.

One more observation is related to the project management dashboard. It seems that project managers need to refer to several tools and documents to check the project performance. In other words, they need to go into several tools like Project plan, SAP, EDMS, SharePoint sites to check the exact status. This process is time taking and certainly unproductive. So the author suggests to create project dashboard for every project. A project dashboard collects, groups, organizes and visualizes all the projects' important metrics, providing a quick overview of project management performance factors. Tools like 'Microsoft Power BI' can be used to create these kind of dashboards.

Organizations needs to use Balanced score cards to clearly identify the parameters for their performance measurement and their metrics. At any point in time, project managers must be aware of the state of the project. This includes incurred costs, level of completion, and estimates of effort required to complete the project. The best project management KPI dashboards enable monitoring key performance indicators in real time. As a result, project teams are constantly informed of project progress and are able to make informed decisions and avoid mistakes.

In this context, the present work suggests that ABB shall implement 'Earned value analysis measurements' (EVA) as project KPIs and create a dashboard based on them. PMBOK (2008) also suggested that earned value analysis is the best way to measure the project performance. The earned value analysis formulas are described in section 2.5.4. If the KPIs for earned value analysis are developed, the data from those KPIs can form a basis for future estimates. For example, earned value analysis method is practically helping to improve the estimates of future projects, based on the best performed project so far.

In addition to earned value measurements, some more project management KPIs can be created

- <u>Missed Milestone:</u> This is the number of missed deadlines in the project, indicating whether capacities of the organizations are overestimated, schedule lags and etc. Generally missing 3 to 4 milestones in a long term project is acceptable, but if it is crossing more than exception the project process needs to be reviewed.
- <u>Percentage of activities completed:</u> Creating this KPI makes sure that each and every activity is monitored in the project. This KPI can be taken as percentage so that size of the activity is not considered. This measurement provides more accurate reporting and understand in what phase the project actually stands. This KPI can also make sure that employees register their hours in proper activities assigned to them.
- <u>Resource Utilization:</u> Resource utilization enables a quick glance at the team's work. Resource utilization measures how the time of team members is used while working on the project. This can be based on the hours registered by employees weekly in the SAP. If the activities are defined based on the documents as suggested in previous chapter, it is easy to segregate them based on the document category.
- <u>Documents Delivery Status:</u> As the main project deliveries are the documents if there is a track of number of documents to be delivered and how many delivered, this gives a pretty good status of the project.
- <u>Average Number of Document Revisions:</u> When the estimations are prepared, estimators always struggle how many revisions of documents are to be considered. So when there is

an aggregated number from each project, it can form a basis for them for future estimate. This number can be grabbed from the EDMS.

6 Conclusions

In today's competitive environment it is necessary to deliver projects on time and within budget. It is challenging for suppliers companies like ABB to increase the efficiency and create value to the customers without reducing the man hour rate. In order to overcome this the supplier companies has been focusing on their own organizational performance improvements and optimization. The present work aims at achieving the organizational performance by considering effective utilization of historical data available for the sales/ tendering and projects within the organization. In addition the study focuses on efficient use and management of lessons learned processes.

As part of this work a case study was conducted in company ABB which is focusing on implementing the use of historical data to provide managers with the right insights for decision-making, in order to plan, optimize and continuously improve organizational performance. To understand the pattern of work process within ABB and obtain measures for its organization performance, number of interviews with experts were conducted. A parametric model was developed and applied for design effort estimation calculations for obtaining improved and optimized project estimation. The model takes historical data variables, project complexity and severity requirements into account and eventually helps to assess the organizational performance.

This is a challenging improvement project as it most likely will involve a considerable change in the work process for many people. Hence a foundation and support from top management to implement this improvement is needed.

The conclusion based on the results are summarized below.

The results from estimation process with feedback loop based on parametric model show that:

- The parametric model has to be established and used for design effort estimation. However organization cannot 100% depends on the parametric model alone. It is recommended to performed expert judgment on the estimate produced by the parametric model to ensure improved level of confidence on the accuracy project estimate.
- Estimation process with feedback loop model can reduce the time required for the entire estimation process. So the efficiency of the sales team can improve by 10 to 15%.
- The project complexity thinking can be applied in the estimation model to provide efficient estimations In addition as complexity assessment is dynamic process and it should be reviewed and updated every time key changes take place.
- A consist utilization of key variables like project complexity and severity requirements in both models of estimation and historical data makes model calculations accurate and clean.
- Organizations needs to establish a single tool for entire estimate process for having same understanding of their project deliveries to customers.
- The service activities in organizations need to be decomposed based on sort of delivery documents for easier standardization of WBS activities and for benchmarking for future projects.
- Development of technical complexity model gains significant importance, by separating technical items from general complexity model. It helps for improved organization performance through avoiding possible future technical risks.

In summary, the sales/tendering process which consists of estimation process in ABB is well defined and structured. But as discussed ABB is not using any models or historical data for future estimate and also the process is missing the feedback loop. So ABB needs to evaluate whether it can make the necessary adjustments as suggested for its sales/tendering process to increase organizational performance.

The results from historical data utilization process shows that:

- The use of historical data shows significant influence on organizational performance through providing benchmarking data, calibrating the project database, creating conceptual cost estimates and schedule, applying strategic project planning, providing trends of customer relationships, forecasting organizational resource and budget.
- The management needs to make sure employees register their hours on assigned activities, So that the data historical data generated from projects is error free.
- Similar activities needs to be selected during the estimation phase and project execution phase as WBS. Then the activities and their databases becomes comparable between estimate and consumed man hours.
- The collection and analyzing the historical data for the projects improves the accuracy of the estimations. However interpretation of the historical data is rather difficult.
- Maintenance of historical data is organizational dependent as different organizations use different systems, tools and process. At the same time the process needs sophisticated software programming tools and integrated with project management tools, which all employees in the organization need to be aware of. The interview results from ABB also confirm this and encourage this automated tools for historical data utilization.

In summary, ABB is making necessary plans to make use of the historical data for resource forecasting, budgeting, etc. But the tools and processes it has, needs to be interlinked together to be able to reduce the manual effort when using them. In addition, top management focus is also required to get the error free historical data by making sure that employees register their hours on assigned activities. Considering the fact that ABB is moving towards digital transformation as it has mentioned in its strategy, using the historical data effectively could be one of the steps for organizational performance improvement. ABB can be a role model if they could able to implement this successfully.

The results from lessons learned show that:

- Lessons learned should be documented and the process shall be developed to capture and compiled lessons learned throughout the project life cycle and distributed as a report among the project teams.
- The organizations need to encourage employees to write the lessons learned by assigning these as target in their performance appraisals. This gives opportunity for every individual employee to be part of improving organizational performance.
- The organizations need to create a single repository database as user friendly webpage for easily accessible, searchable and sortable for lessons learned cases.

In summary, ABB needs to create a single and easily accessible SharePoint site with metadata in its IMS by incorporating the sortable methods.

The results from KPI shows that:

- At any point in time, project managers must be aware of the state of the project. Hence every organizations shall implement ‘Earned value analysis measurements’ (EVA) as project KPIs. The data from those KPIs can form a basis for future estimates and benchmarking.
- Organizations needs to create project dashboard for every project. A project dashboard collects, groups, organizes and visualizes all the projects’ important metrics, providing a quick overview of project management performance factors.
- Organizations needs to use Balanced score cards to clearly identify the parameters for their performance measurement and their metrics

6.1 Future work

- It is essential to separate technical items from complexity calculations for avoiding future technical risks. The present work can be further discussed by developing technical complexity model.
- For the estimation process, estimation model shall account for feedback loop. At the same time, historical data in estimation model need to be treated by sophisticated mathematical models for achieving improved accuracy. A pilot project has to be run for the implementation of these process as well as models and shall be tested on some of the pilot projects for the validation and verification.
- Big data and analytics, Digital oilfield, Industrial internet of things and Secure cloud computing are emerging technical drivers today. Technology advancements has caught up with the needs of many industries, but the oil and gas industry still lags behind in leveraging these advancements. This is for addressing the entire value chain, with focus on innovation and automation. Therefore oil and gas companies must make the leap from the past and adopt organizational performance improvement practices to position themselves for the future.
- The present work has focused on the oil and gas industry tools, models processes, etc. The work can be extended to other industries to make it generalize.
- The study concludes based on the data from only 5 Green/Brown field projects and interviews from selected number of experts. The more refined results can be obtained by applying the models and processes of this work for larger number of projects, in order to ensure that the results are more reliable with consistent confidence level.

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Appendix A – Interview Questionnaire

Project Management / Organizational Performance

1. What is the Critical success factor in ABB?
2. What is the Project efficiency? How do we measure it in ABB? What are the areas for efficiency Improvement?
3. Is there any benchmarking for projects? How do we measure project performance and correlate with other projects?
4. How often does our project manager use a project management methodology?
5. How is the project complexity defined? What sort of improvements does it need?
6. What are the advantages and disadvantages of Lump sum (Fixed price) or Unit price (Re-Imbursable) of project types in ABB?
7. Did you get opportunity participate in tendering / estimation and startup plans? How much it helps?
8. What are the unproductive organizational activities that can be eliminated in ABB?
9. What are the Improvement / Focus areas and best practices?
10. What are all the tools, systems and philosophies in place to review/analyze the work processes? How can we optimize of work processes?
11. How are the Lessons Learnt captured in the projects? How they are converted into actions? If there any tools used for capturing them?
12. How do you make everybody in the project understand the responsibility and act accordingly?
13. What are the KPI's used in ABB? How well they define the project status?

Sales/ Tendering

1. What are the cost drivers most frequently used for estimation?
2. How accurate are the estimated man hours and schedule? What are the reasons for discrepancy?
3. Does project size affects accuracy of man hours and schedule estimation? Why?
4. What are estimation methods used in ABB? To what extent they are used?
5. How satisfied are you with the current project cost estimation?
6. What are the causes of inaccurate estimations? What improvements do you suggest?
7. Can we use some automatic models? What are the barriers and difficulties in using automatic models?
8. Are there any specific assumption that have to be made by estimators in estimating future projects? (any knowledge)

Historical data

1. To what extent the past historical data is useful for estimation of project under present market situation?
2. What is the best way to collect historical data?
3. How can we use the historical data? If you would suggest required improvements in the usage of it. What are they?

4. Creating WBS based on delivery documents. Will it help to use the historical data effectively? If yes how?
5. How accurately employees register their hours in SAP? What about the quality of the data registered?
6. Would you recommend any way to improve how employees can register their hours to increase efficiency of historical data?
7. What is the best way to analyze the data? What are the key variables?

Appendix B – Master Thesis Work Mind Map Diagram