QATAR UNIVERSITY

COLLEGE OF ENGINEERING

TENDERING PROCESS IMPROVEMENT WITH PROTOTYPE DESIGN IMPLEMENTATION

BY

ANOAR ALI AL-RUWILI

A Project Submitted to

the Faculty of the College of

Engineering

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering Management

January 2019

COMMITTEE PAGE

The members of the Committee approve the Project of
Anoar Ali Alruwili defended on 22/11/2018.

Dr. Murat Gunduz
Thesis/Dissertation Supervisor

Dr. Khalid Naji
Committee Member

Dr. Arsalan Safari
Committee Member

Dr. Gulal M Abdella
Committee Member

Approved:

Abdel Magid Hamouda , Dean, College of Engineering

ABSTRACT

ANOAR ALI ALRUWILI., Masters : January : 2018

Masters of Science in Engineering Management

Title: TENDERING PROCESS IMPROVEMENT with PROTOTYPE DESIGN IMPLEMENTATION._Supervisor of Project: Dr. Murat Gunduz.

Failure of projects due to over budgeting, variations and claims as well as delays in the project time line is common in construction industry. This issue is critical, and it needs to be searched in detail for a sustainable solution. One of the main reasons of over budgeting and delays was found to be the undefined scope of the project due to the missing design at the tender stage, the ambiguous and unclear design scope of the project. This forces the tenderers to bid high rates to cover the risk of undefined design scope. The repetition of project design for the buildings with same functionality can easily be applied at different geological locations. This factor can be controlled and eliminated with the introduction of a prototype design model according to the required functionality and concerned polices. The prototype shall be prepared with full consensus of all concerned stakeholders and one of the most effective and efficient existing building of the concerned end user shall be taken as a baseline for the establishment of best possible prototype design models, which shall be applied to all buildings of the same end user anywhere across the state of Qatar. To study the impact of prototype design model implementation on the tendering process, one project is taken as a case study and a prototype design model has been implemented to the existing tendering process. With the implementation of prototype design model to the tendering process, it was found that a 40.7% saving is done in

overall budgeted cost of the project, 39.0% project time is reduced and about 34% of resources were saved, which seems to be a great achievement in solution of the problem.

DEDICATION

I dedicate my project work to the of professionals working with me in project division for their valuable and professional input at the concept development stage of this project.

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ACKNOWLEDGMENTS

First of all, I am thankful to Allah Almighty for giving me ability and opportunity to pursue my dream of getting master's in engineering management. I am also thankful to Qatar University for providing me a highly prestigious platform to get my dream come true.

I would like to express my sincere gratitude to my supervisor Dr. Murat Gunduz for his continuous motivation and guidance in a very professional manner throughout my master project, without his supports I might not able to produce a quality document of my project.

Also, I would like to thank the Engineers in my team of projects division for sharing their professional experiences about prototype formulation and its implementation, as their opinions always added value to my project.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER-1: INTRODUCTION

1.1 Overview

When his Highness Sheikh Hamad bin Khalifa Al-Thani, Father Emir, put forth Qatar's National Vision (QNV-2030), he envisioned a clear path to achieving this vision through the development of a step-by-step strategy that would turn each goal of QNV-2030 into a concrete reality for Qatar.

The five pillars of the Qatar National Vision were agreed to be the following.

- Sustaining Economic Prosperity
- Promoting Human Development
- An integrated approach to sound social development
- Managing Environmental Development
- Developing Modern Public-Sector Institutions

Qatar's National Development Strategy 2017-2022 is a plan of action. It presents new initiatives while building on what already exists. For projects policies and institutions already under way, it provides added impetus and focus. This master project would like to highlight the fifth pillar (Developing Modern Public-Sector Institutions) from the QNV-2030 as the baseline of the study.

Qatar needs strong public-sector institutions to reach the goals of QNV-2030 for social progress, human development and sustainable environment. Achieving these goals will require institutional and organizational capacity building, efficient and transparent delivery of public services.

Two linked concepts underlie the NDS programme for institutional development and modernization. One is the drivers of modernization, factors that influence performance and the need to modernize, and that serve as measures of institutional success. The public sector's efficiency, effectiveness, value development, transparency, accountability, relevance and customer engagement.

The other levers are modernized policies and planning, resources development, organizational alignment, procurement, institutional processes, information technology and performance management.

This project is about the implementation of prototype design on the construction of a repetitive building. The study enhances the existing tendering and budgeting processes by the implementation of prototype design models.

1.2 Statement of the Problem

It has been observed through repeated complaints about the delays in the process of tendering new projects from the initialization till the tender stage of the repetitive projects.

To speed up the tendering stage, it was switched to the contract type of design and build to expedite the tendering process and catch the annual development programme because it is normally assumed that design and bid type of contracts are faster due to the simultaneous work on the design and execution of the project.

However, "design and build" also has difficulties to deliver the projects on time and within the budget only because of the undeclared scope of work and uncontrolled end-user requirements, due to which the tenderers go for high bid values with high factor of safety to mitigate the risk associated with the undefined design scope of the project.

1.3 Objectives

The main objective of this project is to:

- Investigate the real problems in the process of repetitive projects that causes a significant delay, especially in the tendering process.
- Propose improved process to avoid the real root causes of projects delay,
- Achieve the highest possible value of this type of projects and to fit its allocated budget, by introduction of value-based design (value engineered) prototype model utilizing value engineering synergies with six sigma tools.

The objective of this project is to define the existing process of new projects from the stage of initiation to tendering and awarding. Identify the wastes or non-value-added steps in the existing processes and eliminate it to improve the efficiency and effectiveness of the tendering processes for solving the problems explained above.

1.4 Methodology

To solve the above major problems of delays and over budgeting in repetitive projects, which have been observed repeatedly in majority of projects, this project proposes the review of the existing tendering process and find out the wastes in each step of the existing process.

After an in-depth study of the existing tendering process the prototype design model shall be implemented and the tendering process shall be studied again for the impact study and evaluation due to prototype design introduction.

Above process evaluation and impact studies shall be conducted with the following concept of process improvement and waste reduction in any process.

- Draw a macro level mapping of the existing processes
- Identify the non-value-added in the process and eliminate it.
- Draw a micro level mapping for more detailed study.
- Identify the non-value-added again and eliminate it
- Draw a hyper-micro level mapping
- Identify the non-value-added steps and eliminate it.

Repetitive buildings are normally those buildings which are regularly been visited by public to get different kind of services. Such buildings receive thousands of people of different age and sex on daily basis to get their required services done. For example, depositing utility bills, applications for new connections, filing a report in police station, getting doctor appointment, getting admission in schools and colleges, transfer of cars, paying of violations and much more.

The most common factor among all the repetitive buildings is that in most cases their operational and service policies are consistent and well defined. These departments know the expected visited per day as well the requirements of services counters, the capacity of waiting areas, the services required, the parking needed, the orientation of different section starting from reception until the completion of the process and the time consumed on dealing each visitor.

Some examples of public-services departments are:

- traffic department,
- hospitals,
- schools,

- colleges,
- fire stations,
- preventive buildings,
- visa and passport sections,
- police stations and jails and investigation buildings.

All above services department offers similar services and working environment in each of their building regardless of their geographical location, means that the Primary school at Doha shall have the same kind of functional buildings throughout the state.

Therefore, it is required to design and approve a “prototype” design model for a repetitive project based on their requirements about spaces and functionalities which shall be applied to all new projects for any geographical location of Qatar.

This will save a considerable amount of additional cost and time due to the availability of well-defined prototype design, with the implementation of the subject prototype design model the scope of the project shall no more be ambiguous at the tendering stage which shall be resulted in a perfect competition between the tenderers.

With the implementation of prototype design model to the tendering process, it was found that a 40.7% saving is done in overall budgeted cost of the project, 39.0% project time is reduced and about 34% of resources were saved, which seems to be a great achievement in solution of the problem.

CHAPTER 2: LITERATURE REVIEW

This part will cover the review of concepts used in this project in a detailed manner. It will cover prototype concept, tendering process, continual process improvement, value engineering and value stream mapping.

2.1 The Prototype Concept

A prototype is a three-dimensional model of any design for more realistic study of the functionality and effectiveness of the proposed design. Traditionally only two-dimensional designs were used for the evaluation and decision making of project tendering and execution, however, with the introduction of more complex project it was difficult to take effective decision based on the two-dimension designs of the projects regarding the functionality and scope defining. Therefore, the concept of 3D modelling was introduced to study the proposed design in more realistic environment and easy to understand shapes of the proposed design.

Initially the 3D designing models were limited to small scale mass models and study models, then they were upgraded to the 3D digital perspectives and animations, however, these most of these modelling clarifies the distribution of spaces and the aesthetic views of different elevations and interiors.

Prototype is more realist model of the proposed design because it can be even tested for the functionality it is design and intended, in some cases a complete functional model is used to prepared and test as prototype model before the approval of the final design.

Evidence of Principle Prototype Design Model. This type represents basic functions of the original design only without including all functions. Working Prototype design reflect full functional abilities of the final output. Visual Prototype models show the dimensions and finishing looks without functionalities. Study Prototype show the initial status of visual type showing physical dimensions of design model without going in finishing details. User Experience Prototype Models are in fact able to be tested by the experiencing through its end-users, it is a kind of test sample of actual design. Functional Prototype represents both functional properties as well as finishing appears.

To keep the prototype development cost effective and efficient, normally the material selection for it is not necessarily the same as that of the original product, the physical and chemical property might not be the same, however, the material selected shall be able to represent the true image of the actual product.

The fabrication and execution of prototype is also not on the scale, tools and moulds as the final product again to control its production cost because the original product is been produced under mass production which minimise its production cost, however, prototype models requirement are normally less in quantity and sometime only few in numbers and shall not affordable to produce through the same production lines, tools and procedures.

The process of prototype design and preparation passes through a series of quality assurance and quality control procedures to ensure a strict compliance with the required standards and specifications of the design in order to observe real representative of the original product. The quality control includes some detail inspections and repeated trial and error for each major and minor elements of the original product.

The project design consultant in collaboration with all stakeholders decide about the selection of the most suitable form of prototype design model as it keeps changing from case to case depending on the complexity of the project functionality and expected services of the proposed buildings or products.

Gero (1990) started elaborating prototype design models as a process who introduces the concept of prototype for the first time to test and approve it before going in the mass production of the original product. Prototype today is playing a vital role in the concept models creating and product development in almost all commercial markets which are based on product development criteria for increasing the market share and growth.

An uncertainty always remains regarding the functionality and effectiveness of any new product floated in the market (ThomasNet, 2015). Therefore, manufacturers use prototype development before the production of the actual product to increase the chances of effectiveness and success by testing the response of market towards the prototype and plan accordingly.

Getting the results according to the consumers expectations need a process of continual improvement or trial and error design processes of prototype design models, because the expectations of the end-user are so challenging due to the rapid changing markets, the demands of end-user are keep changing and the canvas of expectations is keep increasing. Therefore, the role of a research and development departments is very important in the development of an effective prototypes designs and the final product development.

2.2 The Tendering Process

Construction tendering is the process of receiving commercial and technical offers against the project announced for procurement and construction. Normally the owner of the project defines what he wants at the tender stage and invite quotations and offers by the selected suppliers and contractor who have been prequalified by the owner of the project or his consultant.

The factor which directly affect the tenderers prices in the bidding is the total required quantities of material and deliverables and their specifications, if the BOQ quantities and material specifications are well defined the tenderers feel more confident in quoting best competitive prices without feeling any risk of increase in the scope or specifications. Prototype development and inclusion at the tendering process makes this possible because if the prototype is available, that means a very well-defined scope of work is available and all the specifications, method statements and required resources can be estimated easily.

Bid solicitation is the process of advertising the project charter with some basic information to attract the interested contractors and suppliers for further negotiation and offering against the scope of the announced project.

There are multiple project delivery formats, however, it depends on the project charter and complexity to select the format which shall be best suited for the circumstances of each project because each project delivery type has its pros and cons. Following are two most popular and frequently used project deliver types with brief definitions.

Under design-bid-build delivery system, the owner hires an architect or a design consultant for the project design, scope definition, specifications, working drawings, estimates and bill of quantities. The design consultant is responsible to prepare tender documents for the tendering process of the project.

Therefore, under this type of project delivery, the owner signs multiple contracts, one with the design consultant and other with the general contractor, with the project supervision consultants as well as nominated sub-contractors.

In some of the large size project the design consultant keeps some budget for the provisional sum of undefined scope during the tendering stage, which is also an indirect contract with owner because owner is responsible for the variations in the cost of provisional sum which also add risk of cost variations for the owner. For minoring and controlling these stakeholders the owner needs a supervision consultant as well.

This type of project delivery is suitable for small scale projects only, the reason is with increase in the scale of the project the numbers of contract with owner keeps increasing, for example the owner will need a supervision consultant as well to ensure the correct implementation of design and quality execution of the project.

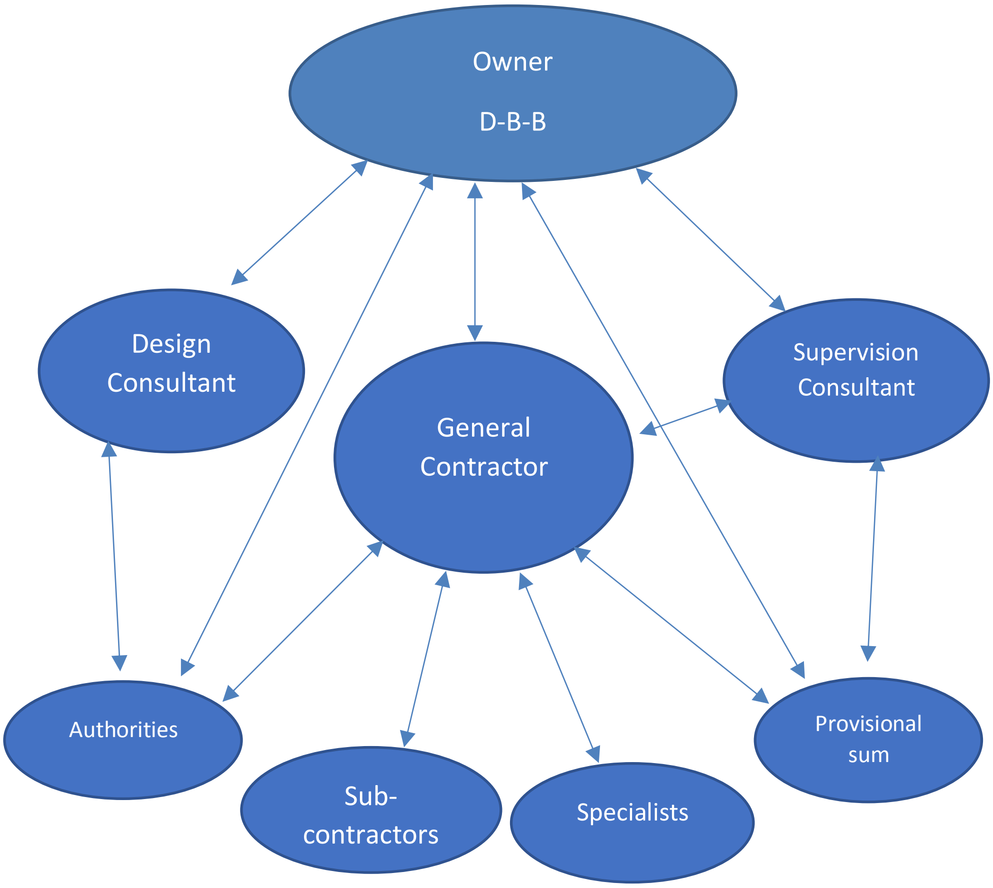


Figure 1 design-bid-build project delivery

As shown in above Figure 1, the owner has many points of contacts and dealings which normally result in huge tension and conflicts of diverting the responsibilities to each other, promoting blame-game in case of any variations and scope deviations.

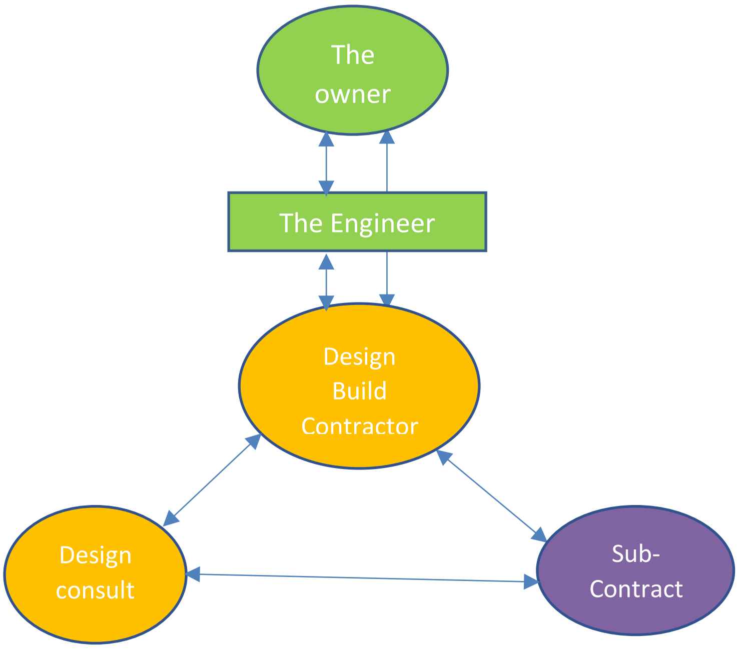


Figure 2 design-build process

As shown in above Figure 2, design build format of project delivery is very simple and easy to handle from owner point of view, here the owner has only one major point of contact and that is his Engineer who is appointed to monitor and control the design build contractor and make sure the accurate implementation of approved design of the project as well as control the scope deviations, progress, variations and claims and payments verification and approvals.

Due to its simplicity and reduced risks of conflicts, most of the state departments has adopted this kind of project delivery.

A specific design is only required for building whose functionality are either not defined or not consistent in nature to suit the existing format of its buildings.

Therefore, this project is designed to implement a prototype design model on a project with clear and confirm functionalities, this will eliminate the requirement of design from above contract a new type of project delivery methodology can be produced as following.

The reason why prototype implementation is supported and advised for the repetitive projects is shown in above figure 3, it has made the delivery of the project simpler and with great control on the scope deviation and time line of the project due to the very well-defined scope in shape of prototype design.

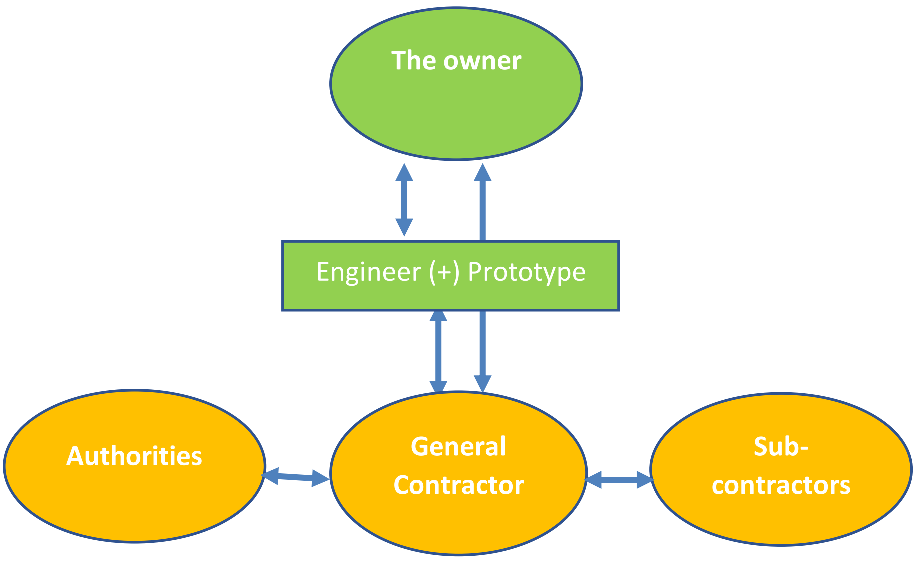


Figure 3 project delivery after prototype implementation

2.3 Continual Process Improvement

Continual process improvement means the incremental improvement of any process to achieve a highly effective and efficient process. One of the most popular concepts in use for exercising the continual or continuous improvement is the one introduced by Deming who is considered as the father process improvement concept.

According to Deming is almost impossible to get a 100% effective and efficient process with putting it in a series of trial and error.

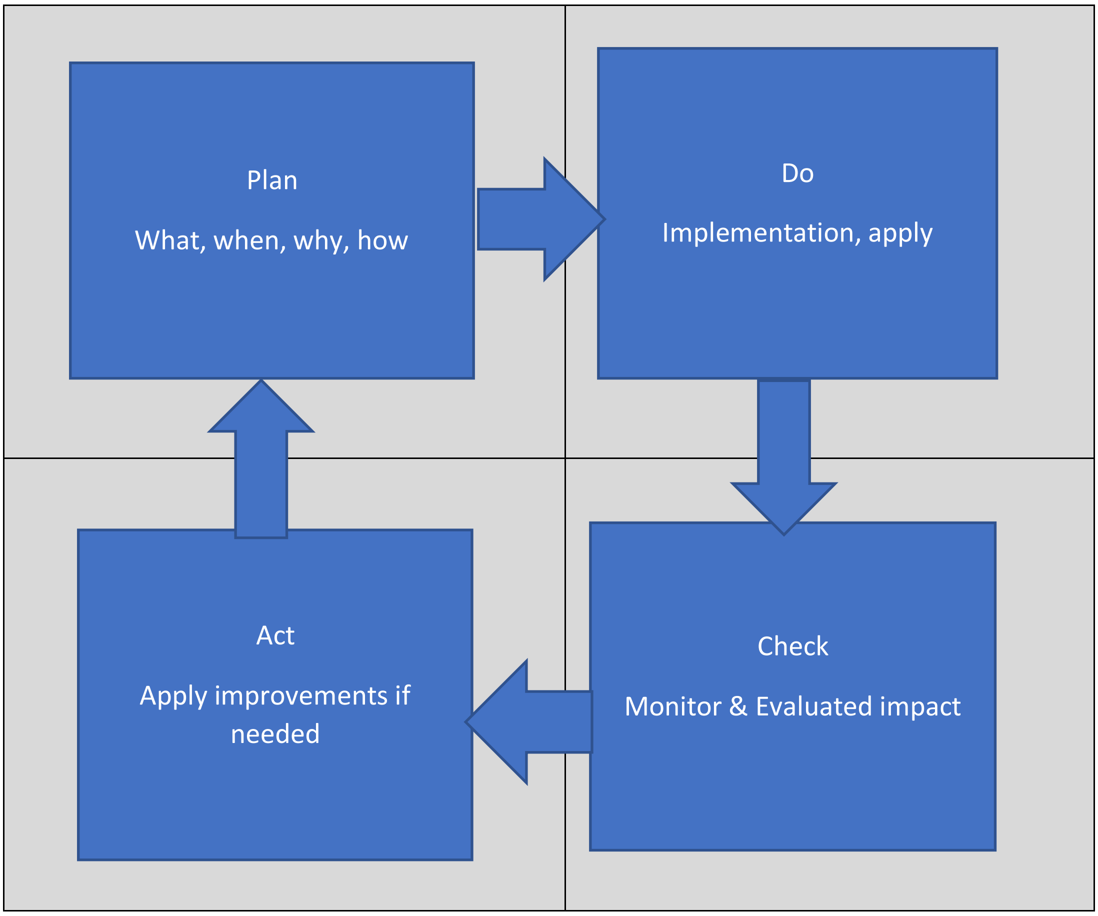


Figure 4 Deming cycle of continual improvement

According to (ASQ, 2018) "Continuous improvement, sometimes called continual improvement, is the ongoing improvement of products, services or processes through incremental and breakthrough improvements.

2.4 Value Engineering

VE is a systematic approach to solve problems, it succeeded in technological advanced countries, and the secret of its success is the ability to identify unnecessary costs with improves both of quality and of performance. (Alyoussfy, 2006). VE is an organized approach aims to search for cost, which does not serve neither the quality objectives, utilization, durability nor appearance. (Dell A.,1982)

Value Engineering is in fact a progressive methodology to add value to the products before introducing in the market, the value adding can be done by adding more properties, features or functionality to the product against it cost. In other words, value of the product can either be increased by increasing its functionality without increasing its cost or reducing its cost without compromising on its functionality and quality.

Value Engineering was tossed for the first time during the second world war in USA when there was a critical shortage of production resources in the market, the fixed and variable cost increased and it was difficult reduced the production cost of the products, so they focused on increasing the functions and features of the products without further increasing its cost which helped in adding values to the product and the buyer was ready to pay more due to its high value. Theway introduced the methodology of VE by using FAST diagram tool in 1964. (Alyoussfy, 2009)

After the success of VE methodology, many societies around the word interested in the dissemination of this concept, like Japan in 1970, and then in Europe in 1975, and in Saudi Arabia in 1987 and in Egypt in 1998. (VE workshop, 2008)

The value adding to the product shall be part of each employee starting from the concept development till the final production, packaging and distribution, each and every stage is designed to add more values to the final product functionalities and features. It is a result of a perfect teamwork in the right direction.

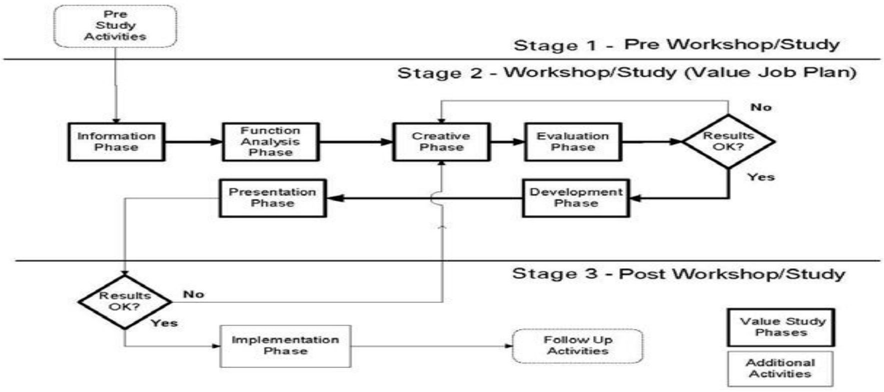


Figure 5 value engineering tools

The research and development department conduct research to identify the actual requirements of buyer and end-user through in depth and realistic surveys. Once the end-user demands and complaints are known, a new product design concept is prepared which after passing through different stages take the shape of final prototype design model which finally is introduced for end-user response.

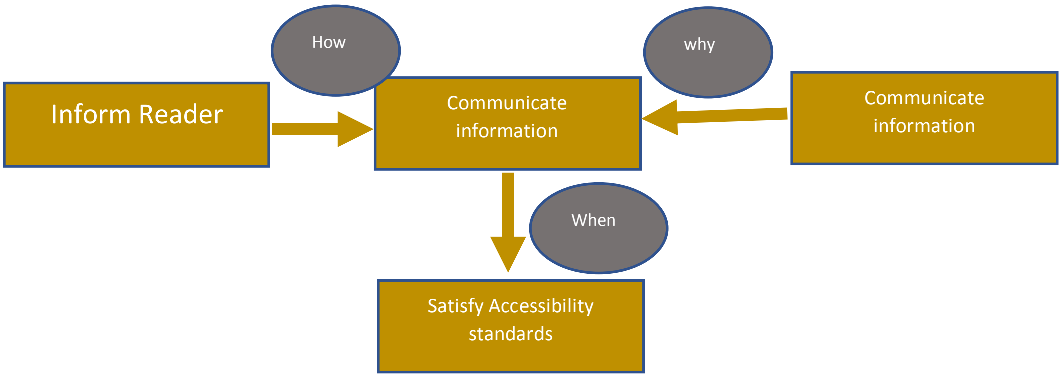


Figure 6 value engineering tools

The research and development teams are always in search to find tools and techniques for adding more functions and features to the final product without increasing its production cost which ultimately add value to the final product and adding value means increasing the end-user's level of satisfaction

Sometimes alternative design options with equal weightage are introduced to the end-user through prototype models and a comparative study of response is conducted to select the best possible design model.

Value Engineering considers total cost, based on the building Life Cycle Cost Analysis (LCCA). LCCA address the reduction of total cost of a building right from its concept development till the operations and maintenance costs, known as "whole cost accounting" and sometimes "total cost of ownership," LCCA consider the initial cost of the building construction till the operation and maintenance by using different value engineering tools and techniques.

LCC includes some of the major areas which are normally considered during the value adding process by keeping the life cycle cost as much as possible by concentrating on the reduction of following cost areas of a building or product.

1. Initial Cost
2. Execution Cost
3. Operational Cost
4. Maintenance Cost
5. Services/ Utilities Cost

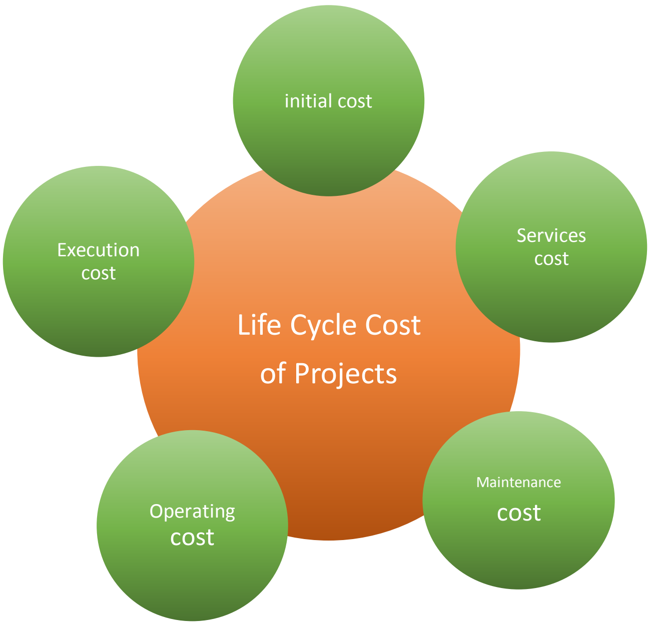


Figure 7 value engineering tools

The research will define recommended VETs that can be used in the workshops during the design process to help the teamwork in data analysis and decision-making.

2.4.1 pareto diagram

According to PARETO 80% of the problems are caused by 20% of reasons or factors which taken from the fact that 80% of the world wealth is owned by only 20% of people. PARETO diagram consists of four axes as following: (PARETO diagram, 2018).

The following figure 8 on page 27 is explaining this concept in detail were the vertical lines are representing the percentage of cost items and total accumulations. The horizontal axe is reasons or items. The cumulative function is a concave function. PARETO Diagram usage: Divides the big problem into smaller parts, which can be easily analysis. Facilitates to identify important causes of the problem; Clarifies the improvement areas, which will be focus in; Helps for guidance of optimal use of available resources; Helps for taking the problem-solving decisions based on facts.

PARETO diagram has applied in VE study for building MB4 in technology park-Egypt in 2010 to Analyse the cost items of the electrical works, as shown in Figure

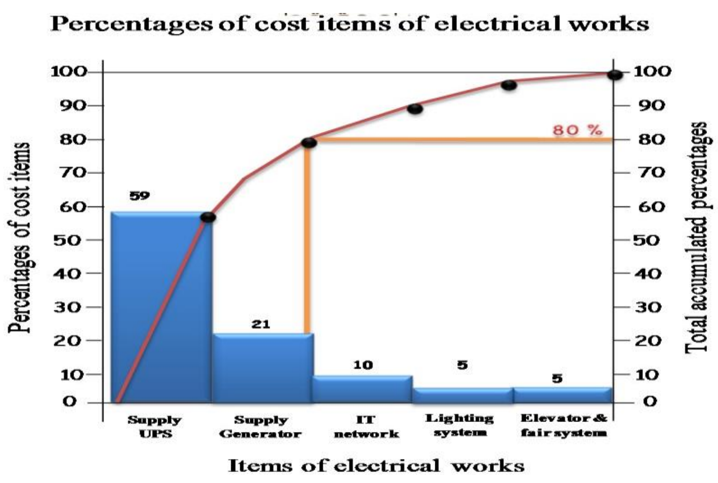


Figure 8 pareto diagram Source: improvement studies,VE, 2010

2.4.2 quality model (star model)

It is a kind of polar or radar chart forming a graph that show the comparative data of several design criteria and options for different scenarios. The same axes (poles) are used to display the data for different cases reflecting different situations.

VE Quality Model or star model is used as an evaluation tool which is based on identifying the quality key items (evaluation criteria), to make a comparison between two design situations or options. Usually, VE team is applying it to compare between before and after a proposed development.

Quality Model has been applied in VE study for building MB1 in the technology park-Egypt in 2010, the VE team worked on evaluating the HVAC system, before and after the design development.

Figure 9) shows the quality model components and the evaluations of HVAC system designs.

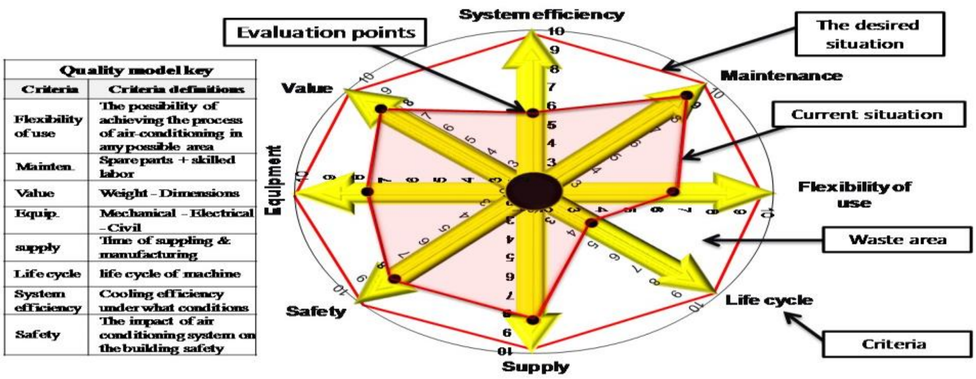


Figure 9 quality model components

Source: Improvement studies, Quality Model, 2010

VE team used the Quality Model in both of data collection and search and development steps to evaluate the pre-design and developed design for HVAC system.

2.4.3 fish bone diagram benefits:

All concerned parties to Analyse the problem and detecting potential problems. Increase knowledge of the details of the production process or service and determines data collection scope.VE team studied the expected problems of executing and supplying the UPS. Figure 10 shows Fish bone diagram.

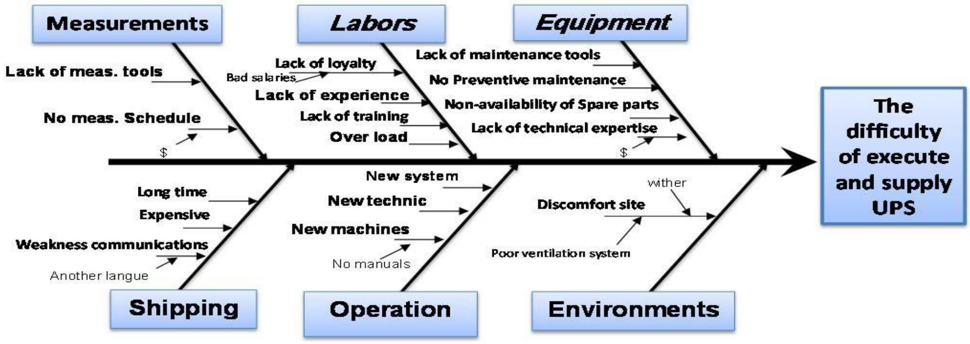


Figure 10 fishbone diagram

Improvement studies, VE, 2010

VE team used the fishbone diagram in the idea generation step; to Analyse the probability and reasons of a specific problem that may happen, to develop ideas which, avoid those reasons.

2.4.4 affinity diagram

Affinity Diagram combine display different options and ideas collected during the brainstorming sessions for better and effective decision making for choosing the right alternatives. (Naagarazan, 2009). Figure 11 shows an Affinity Diagram.

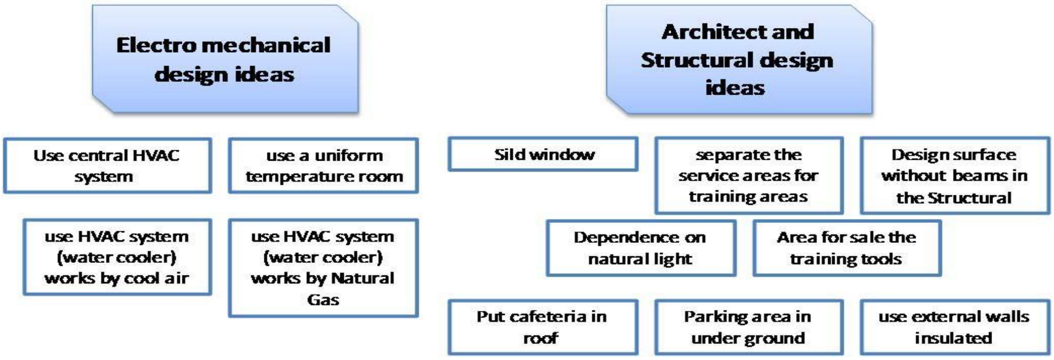


Figure 11 affinity diagram- value engineering tool

Source: Improvement studies, Affinity diagram, 2010

2.4.5 function analysis system technique (fast)

A tool representing the answers of most important questions “How and Why” in a graphical way for effective analysis of relationships between the functions and final product or services. The logical relationships are based to get objective solutions in defining the scope and functional relationships of the product or services.

Fast diagram is used to know and define all required function of the final product or services. This diagram is normally used to identify, and illustrate how, a proposed solution achieves the needs of the project, and to identify unnecessary, duplicated or missing functions.

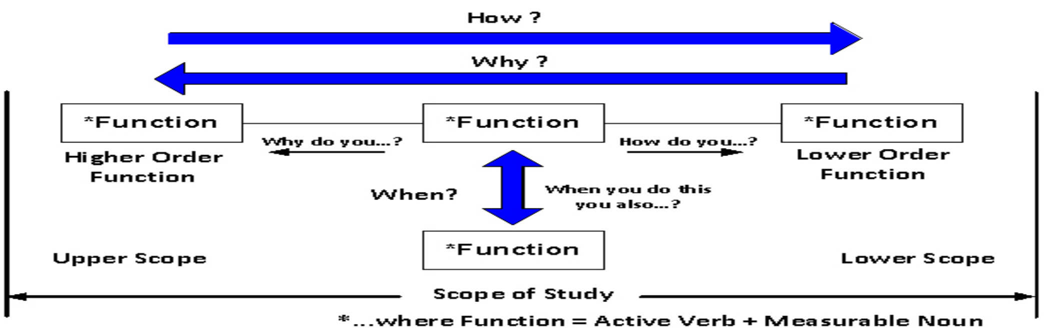


Figure 12 value engineering tools

The development of a FAST diagram is a powerful thought process which supports communication between team members.

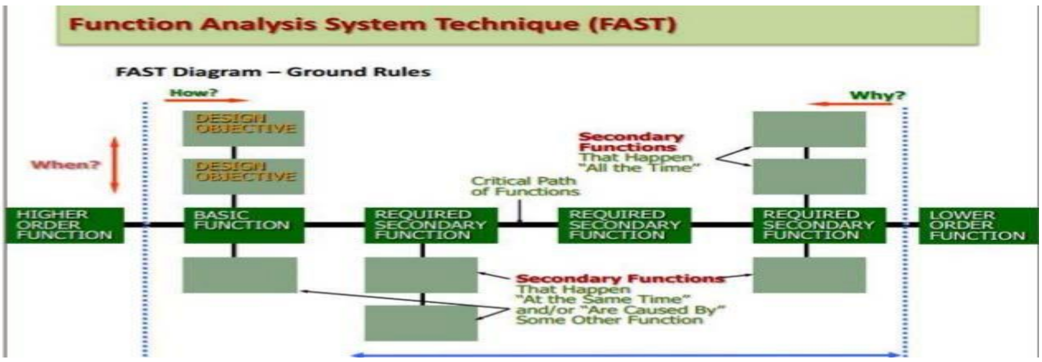


Figure 13 value engineering tools

2.4.6 quality base selection, QBS

QBS is a VE tool which being used in compassion and selection between several alternative based on its quality and total cost. It consists of two parts.A set of criteria to be identified for the comparison of several alternatives. These criteria must be not monetary, i.e., the cost is not one it criterion.

Determine the priority of each criterion by defining the weight of each. The priority is determined by voting among the members of the team. There are three levels of preference for the criteria.

Much better: to be rated by two degrees to the best criterion and symbolize it as follows: (the character that represents the best level followed by number 2), for example (B 2).Slightly better: to be rated by one grade to the better criterion and symbolize it as follows: (character that represents the best level followed by 1), for example (B1).

Equal in preference: to be rated by one grade for each criterion and symbolize it as follows: (letter / letter), for example (B / C).

To weight the criteria by comparing rating every criterion versus each other one.The total weight of the criteria is then calculated by determining the frequency of the above given rate, as shown in Figure 00-00.

Determine the percentage rate of each weighted criterion, using the following equation.

$$\text{Weighted Criterion percentage (\%)} \quad \frac{\text{Weighted Criteria Rate x 100}}{\text{Rates Sum}}$$

Part one		Weighted Criteria,					
		Criteria					
	A	Power Saving	A				
	B	Easy to operate	A \ B	B			
	C	Cooling quality	C 1	C 1	C		
	D	Quietness	A \ D	B \ D	C 1	D	
	E	Indoor Unit shape	A \ E	B 1	C 2	D 1	E
	Weight		3	3	5	3	1
	Percentage (%)		20	20	34	20	6

How Important

2 points for Major Preference

1 points for Minor Preference

1 point each for Same preference

Figure 14 value engineering tools

The team need to develop a six-column table, as follows:

Column 1: Alternatives or proposals in the first column are placed below the Criteria column from the first part.

Column 2: To rank and evaluate each alternative against each criterion, by the average voting of the team preference according to the below ranking.

Excellent: 5 degrees Very good: 4 Good: 3 degrees

Accepted: 2 degrees **Poor: 1 degree**

Each alternative raw is divided to two sub rows. The upper one is for alternative evaluation rank against the criteria and the lower raw is for the Alternative weighted evaluation rate to each criterion (Result for the nearest decimal number), as per following equation.

Alternative weighted evaluation rate = Evaluation rank x Weighted

Criterion percentage

Column 3: The Quality value of each alternative is the sum of all criteria weighted evaluation rate for each alternative or proposal.

Column 4: To Estimate the total cost (LCC) of each alternative.

Column 5: To Calculate the Value Index by the following equation, (the result is written to the nearest integer)

$$\text{Value Index} = \frac{\text{Quality value}}{\text{Life Cycle Cost (LCC)}}$$

Column 6: To Calculate the Value Index Percentage for each alternative or proposal, to choose the best of the alternatives according to quality and the total cost (LCC) by the following formula, (the result is written to the nearest integer).

$$\text{Value Index Percentage} = \frac{\text{Value Index x 100}}{\text{Highest alternative value index}}$$

	QBS									
Part One	Criteria									
	A	Power	A							
	B	Easy to	A	B						
	C	Cooling	C	C	C					
	D	Quietness	A	B	C	D				
	E	Aesthetic	A	B	C	D	E			
	Weight		3	3	5	3	1			
	Percentage (%)		2	2	3	2	6			
Part Two	Alternatives		Alt. Weighted rate					Q	L	V
	Alternativ	r	5	5	3	1	1	3	1	2
		r	1	1	1	2	6			
	Alternativ	r	4	5	4	4	3	4	1	3
		r	8	1	1	8	1			
	Alternativ	r	3	5	5	4	5	4	1	2
		r	6	1	1	8	3			

<u>How Important</u>

1 point for Minor

1 point each for

Q	Quality	- V.I	Value Index
- L.C.C	Life Cycle Cost	- V	Value Index Percentage

Figure 15 quality base selection of the optimal alternative

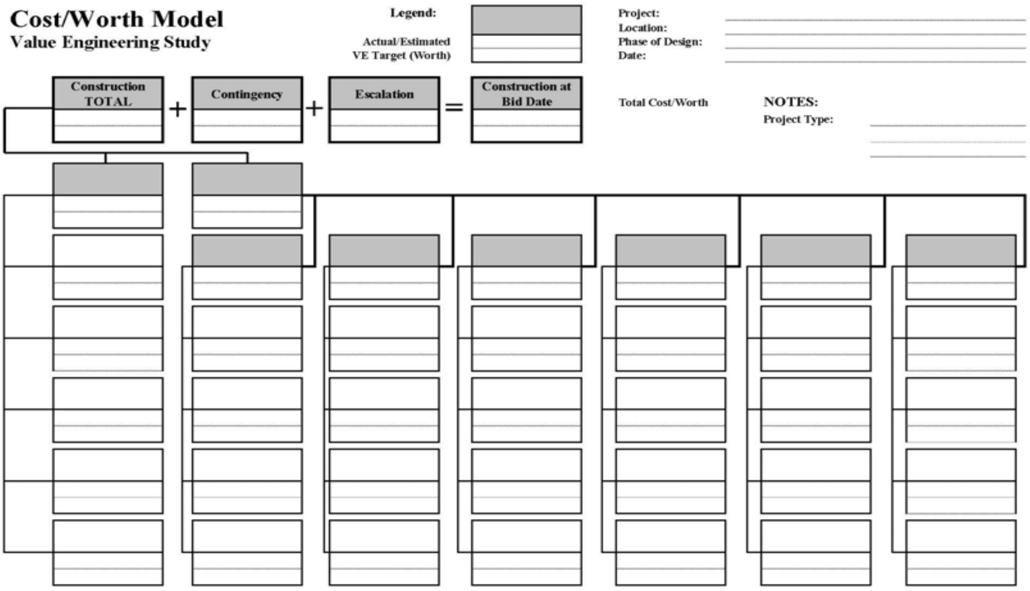


Figure 16 value engineering tools

Life Cycle Project Cost Analysis Form

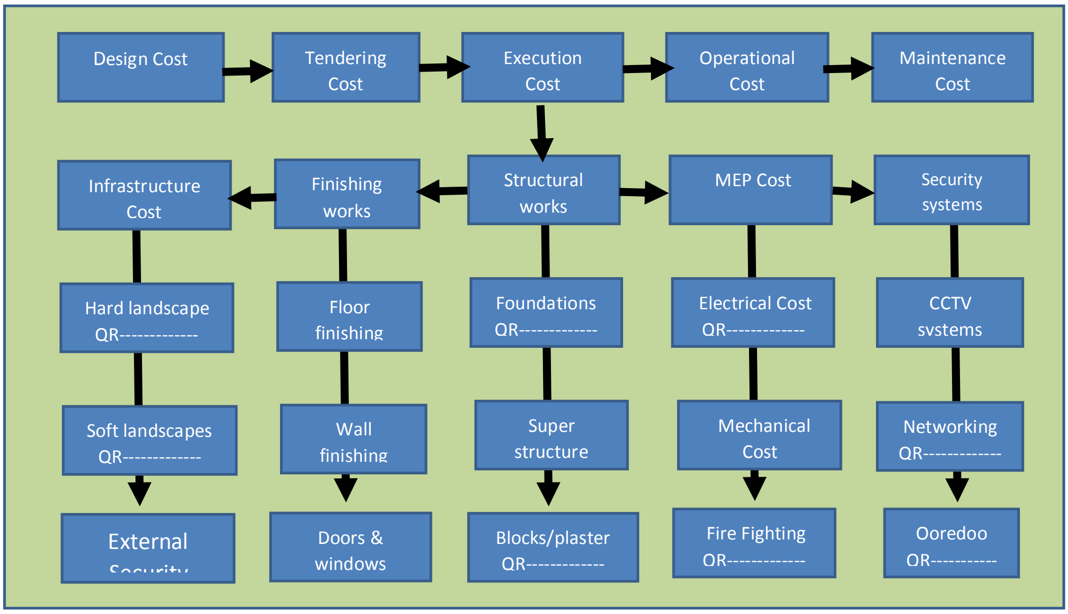


Figure 17 value engineering tools

2.5 Value Stream Mapping

The purpose of value steam mapping is to study and find any loop holes and wastes in the existing processes, it is not possible to improve any process unless their existing status is properly evaluated for the presence of non-value-added activities which are known as wastes of the process as well. Once the wastes or non-value-added activities are identified it will be easy to eliminate them form the system which will increase the process effectiveness and efficiency.

After mapping all the existing tendering process, to initiate, design and tender new projects, the next very important process is the Total Waste Reduction for the elimination of all non-value-adding steps from all existing processes to save time and resources and make the new processes not only effective but efficient as well.

Total Waste Reduction (WTR) is a structured approach meant for all industries of manufacturing, services, software, commercial, etc. and focuses on improving quality, productivity timeliness, flexibility, safety and even the morale of employees by utilizing the various methods of work simplification, redesign of products and processes and waste elimination/reduction.

It covers both types of wastes business related wastes and work area or shop floor related wastes. It recognizes that any work generates both value-adding content and non-value-adding contents and squarely deals with the latter

The basic goal of TWR is to lower the time, money (cost) and other resources required for any or all activities within or outside the boundaries of the production system. The core objective of TWR to an address non-value-adding activity with a view of their elimination. Some authors have referred to this approach as cycle time reduction since by reducing wastes, cycle time automatically comes down. Similarly, some have claimed it as a cost reduction exercise as it enables the search for unnecessary activities and processes and the various costs associated with the non-value-adding work component and addressing them squarely. In this way, costs come down and margins or effectiveness improves.

The first step towards wastes elimination is the analysis of the existing processes for the nomination of value-added and non-value-added steps in the processes. The following matrix is used to be implemented for the identification of non-value-added activities of the existing process.

The basic concept of value stream mapping is to draw the existing process in shape of a flow chart to study and understand any loopholes in the existing process, once the wastages and loopholes are identified a corrective action are planned to eliminate the wastes and weakness from the system and propose a modified process.

Wastes are non-value-added activities which shall be either eliminated or reduced to the maximum level if elimination is not possible.

When all wastes are identified and removed, only the value-added steps remain part of the process which results in extremely effective and efficient process.

Type of Wastes.

- Errors

  Any kind of deviation from the design specifications and requirements.

- Extra-Production.

  Unnecessary and extra production of product and services is also considered as waste in the process.

- Activities on Hold.

  The holding of successors for the completion of predecessors is also considered as waste the process.

- Non-utilized resources.

  Resources that are not used effectively and efficiently.

- Movement.

  Movement of activities or documents from one place to other for completion and decision making is also considered as waste in the process.

- Stocks

  Stocks, inventory or information laying idle in the process and not been part of input of the process is used to be removed as well.

- Motion

  Unnecessary shifting of resources from one place to other for the execution of its task is also considered as waste, the resources shall be located in locations require minimum shifting for the task completion.

- Over Processing

  Executing any activity or including any input not required for the process is also considered as waste and shall be avoided.

The macro level is the big picture on organizational level, providing the information about the main steps in the process. The macro mapping is largely for the top management or decision makers to see only the main steps that comprise the process and to understand the overall scope of the process.

Micro level techniques essentially depend on the type of waste under consideration. Micro level is close study of an individual activities of the macro level and gives more detail about each activity, which can help to find the pros and cons and effectiveness of each step of the process within the organization.

The hyper Micro Process mapping is required if additional breakdown and in-depth study of the process is required. If the micro level mapping is not able to fully reflect the complete process and effective improvement is not possible, then hyper micro layers are introduced which further breaks down the activities of micro levels in more small and measurable units.

To further classify waste and better understand them, it is better to think of four different levels. First level includes wastes due to cross functional issues, poor communication and coordination between vendors and intermediate customers, and even poor investment decisions. It includes wastes due to poor product and process designs and technologies choices. It also includes waste due to wrong location decisions or even sourcing decisions.

Level 2 includes faulty production planning and control and poor layout, resulting in back-tracking and unnecessary movements. These wastes include poor machine capability, resulting in rework, scrap and ejection, and poor maintenance policies.

Level 3 includes issues such as too much time spent on set-up activities, adjustment and alignment and poor equipment or machine maintenance. It also covers poor workplace design and use of unsafe methods.

Some authors have called level 4 work as machine or operator level wastes. Therefore, the issues involved include improper posture, stress on the back, lack of stock, lack of proper training of operators and lack of a standard operating procedure (SOP).

The best way to eliminate these useless and non-value-added activities from existing tendering process is to introduce a prototype design according to the exact requirements and functionality. Once the prototype is approved with the consensus of all major stake holders, the processes of designing, estimating and constructing will be much economical and faster than the existing process.

CHAPTER 3: RESEARCH METHODOLOGY AND DATA ANALYSIS

3.1 Value Stream Mapping

Value stream mapping helps in creating easy to review and understand the whole process in one window. For example, it breaks down the complete project of building construction in small and easily measurable activities like mobilization, earthwork, foundations, super structure, finishing, MEP, security, landscaping and infrastructure for in depth over view to find any wastes and plan for its removal from the process.

In case the infrastructure improvement is required, and micro level mapping is not enough for effective improvement, then hyper micro mapping is done, and the infrastructure is further divided in smaller activities like soft land scaping, hard land scaping, traffic flows, external parking and security fencing.

There shall be an announcement of tendering process reforms committee who shall study all aspects of the process evaluation and building of a suitable prototype design model.

The committee shall conduct surveys, interviews to study all existing buildings under the use of different groups. Top 3 best functioning buildings shall be selected from the list of existing buildings.

A brain storming sessions and workshops shall be conducted with each group to discuss the pros and cons of the top 3 best functioning buildings under them. The goal for this exercise shall be the section of one design with best possible functionalities.

Value Engineering will be involved as it is one of the most effective methodologies that work on improving three main areas, which are building efficiency, quality and enhancing life cycle costs of the project. Value Engineering study to be implemented to the selected design to assure achieving an optimum balance between function, performance, quality, safety, and cost. The VE team will include a representative from each end user to consolidate the understanding of all functions and its requirements. Accordingly, BIM model will be developed to be used as fully coordinated design for each prototype after conducting and retrieving all clashes detected while developing the Prototype Model.

The finish mass model shall be approved by the concerned team. Once the physical study and mass models, 3D images, 3D animations and walkthrough based on complete detail design are approved, the tender drawings, specifications and budget estimates shall be prepared for each approved prototype design.

There can be multiple prototypes such as type-A, type-B and type-C, in case different sizes are required based on the populations of the area.

The final files shall be saved in a database and to be modified for each new project by only changing the names and locations of the project.

3.1.1 internal structural improvement

The internal structure for the tendering process needs to be improved for better efficiency of repetitive projects.

3.1.1.1 roles and responsibilities

Roles and responsibilities of each group in the tendering process needs to be organized for better efficiency.

3.1.1.2 levels and flow of documents across functions

Table 1 shows that a typical style of document movement form one level to the other in upward direction crossing four tiers to the reach to the top and comes back following the same protocols, takes a considerable time in final decision making.

Table 1

Vertical Organizational Flow of Documents

Project Section Flow of Documents

Levels	Contracts	Drawings	Correspondences	Submittals
Lead Engineer				
Project Coordinator				
Project Manager				
Planning & Design				
Discipline Engineers				

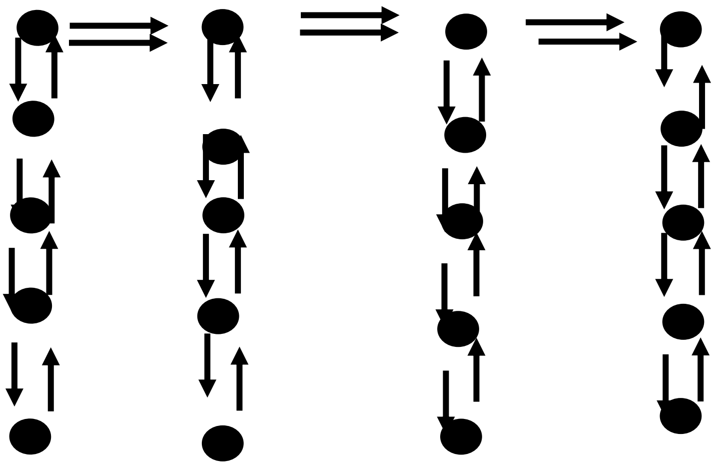
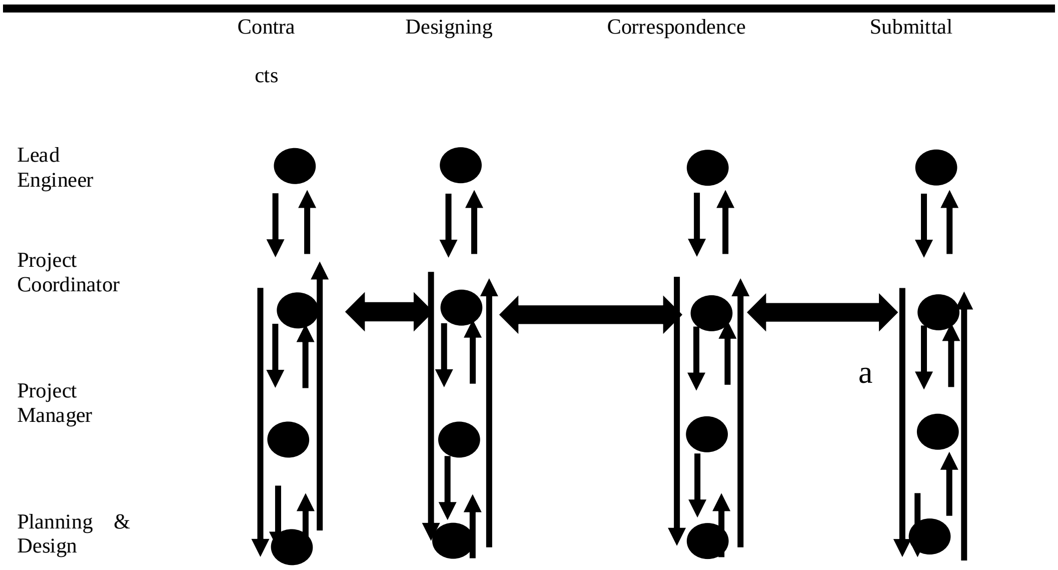


Table 2 shows the documents flow in a flat or horizontal organizational structure where very few or no levels of middle management, believes in team work and full communication in all directions across the groups, due to the ease of direct communications and discussion getting approvals from the leaders and top management is much easier and faster.

Table 2

Flat Organizational Flow of Documents

Project Section Flow of Documents



After the implementation of the prototype design models it is possible to adopt this style of communication regarding the selection and tendering of projects based on already approved prototypes design.

3.2 Existing Tendering Process

Figure 18 shows the process of projects initiation till the tendering with the total estimate time frame of 369 calendar days divided in three phases.

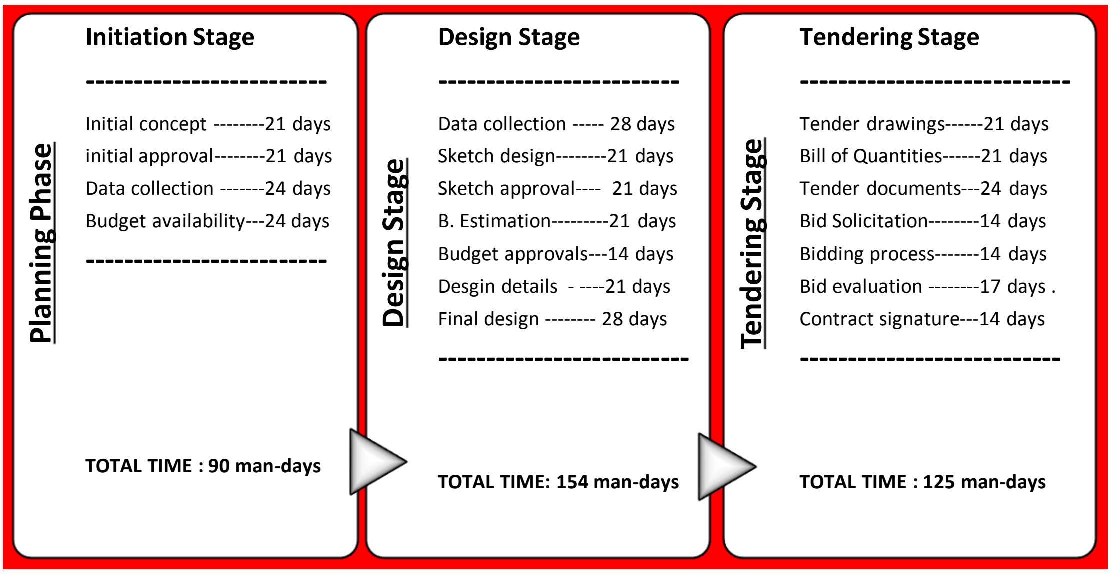


Figure 18 existing tendering process (369 man-days)

Figure 19 shows the distribution of time in three phases of overall process with designing phase consuming the maximum time of 42% of the overall process.

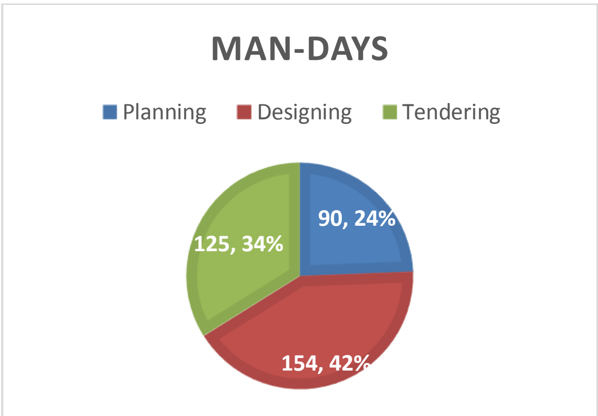


Figure 19 existing process time distribution (369 man-days)

3.3 Modified Tendering Process

Figure 20 shows the impact on the overall process due to the implementation of prototype design, an overall saving in time line is recorded as 144 days which about 39% of the existing process time frame out of which 105 days are saved in the designing phase of the existing process which directly because of the prototype design implementation.

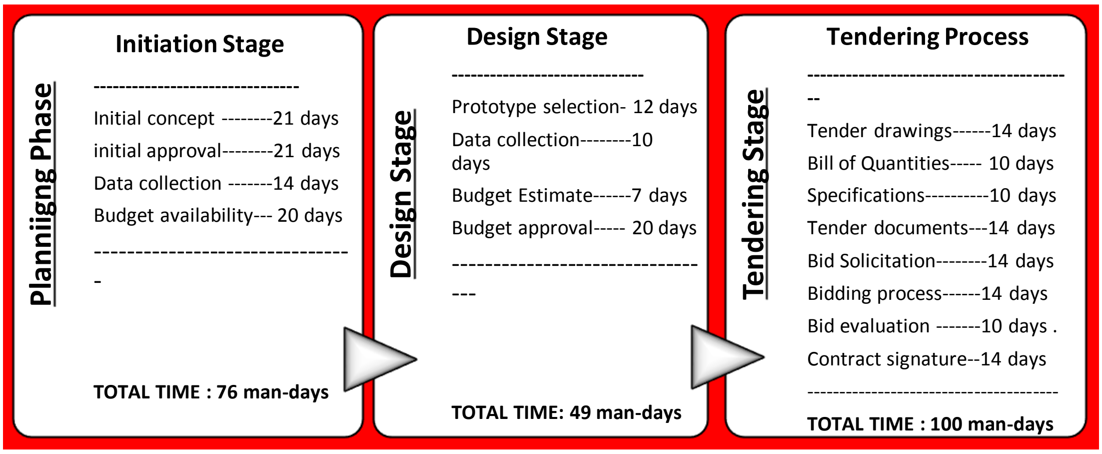


Figure 20 modified process after prototype implementation (225 man-days)

In figure 20, we can see the time savings achieved in each phase of the existing process due to the implementation of prototype design model.

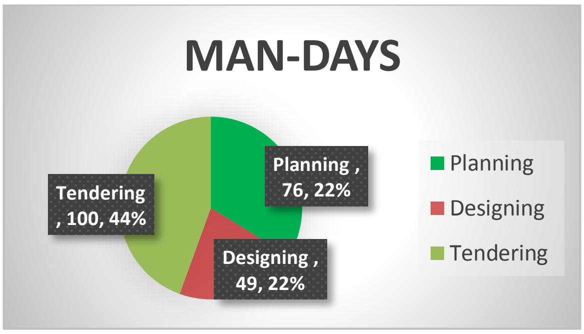


Figure 21 time distribution of modified tendering process (225 man-days)

3.4 Research Methodology Steps.

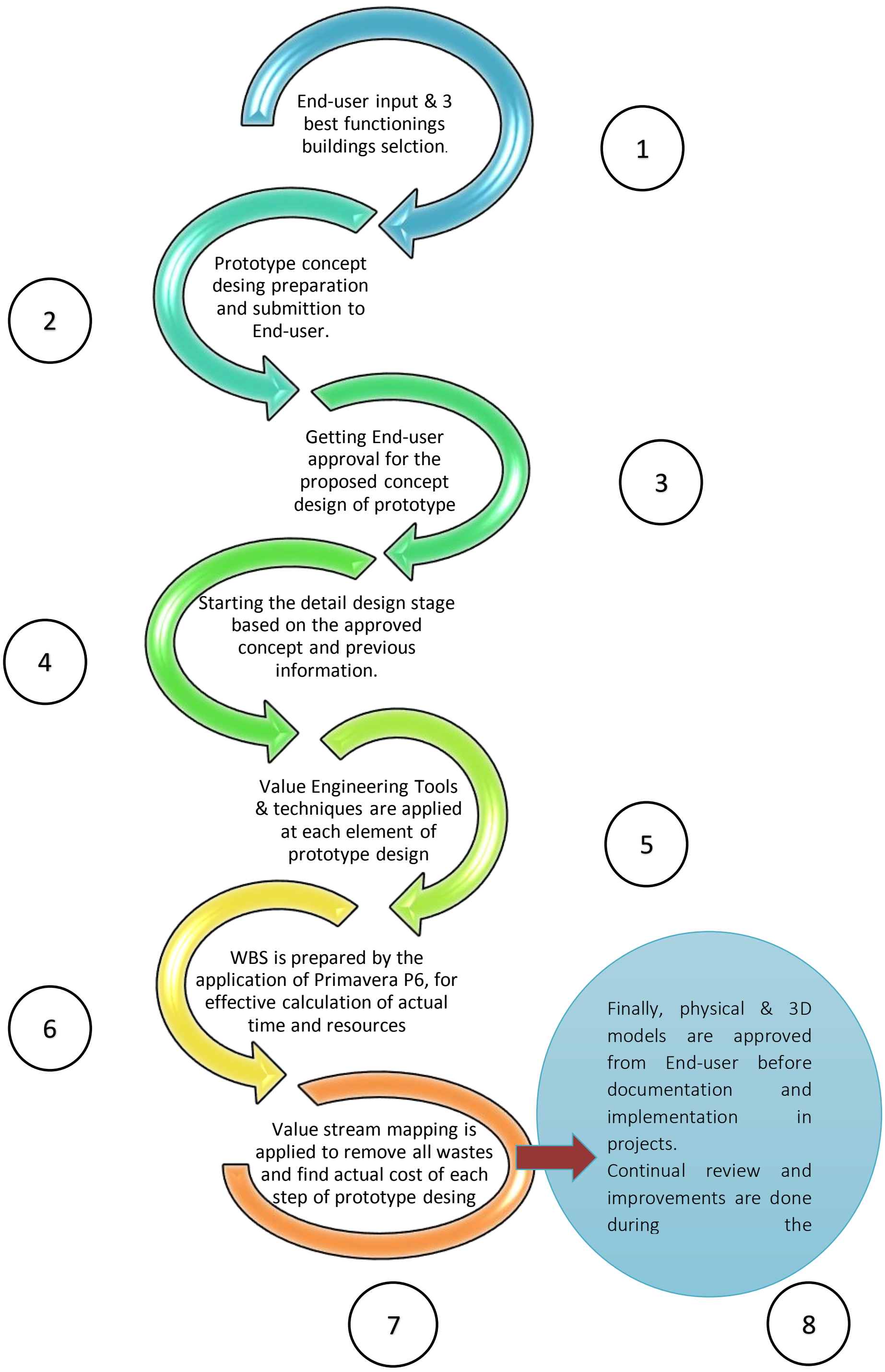


Figure 22 research methodology steps diagram

3.5 Primavera P6 data analysis

The purpose of developing these baselines of the subject tendering process is to study and evaluate its improvement in more details by developing some comparative histograms, flow charts, data comparison sheets, resource distribution graphs because Primavera P6 is very professional in comparison of data before and after the implementation of the prototype models.

To monitor and control the progress of the modified tendering process P6 can revise and update it any time during the execution phase of the newly developed process. This can help us encounter any waste and errors to consider for rectification which will ensure the process of continual improvement of the tendering process.

Primavera P6 has been used to develop the baselines of the existing and as well as the modified tendering processes due to the implementation of the prototype design models. It is a project management tool and it stands out as one of the most easily recognized and useful tools in effective project management, it reduces the risks of the project, easy to use, optimize resources, enhances visibility, forecasts activity progress, it has a tracking features, it enhance project communications, gives the project baseline to monitor and control execution of the project, it enhance the collaboration and disintegrate the whole project in small activities, however, it has still some limitation and one of the most critical limitation is its failure to improve the process at the activity levels of the work break down structure. Primavera can control the progress and sequences according to the relationships established but it fails to suggest the improvement in the activity level processes or removal of wastes from for making the activities completion more efficient and effective.

To review, improve and add value to the activity level processes, we need an effective and reliable tool, the best suitable tool for this situation is value stream mapping, which is a lean management tool, it is not only efficient but also effective, therefore, the combination of P6 and value stream mapping can result in an overall improved and precise processes from macro (discipline level) to micro (activity level) of the project.

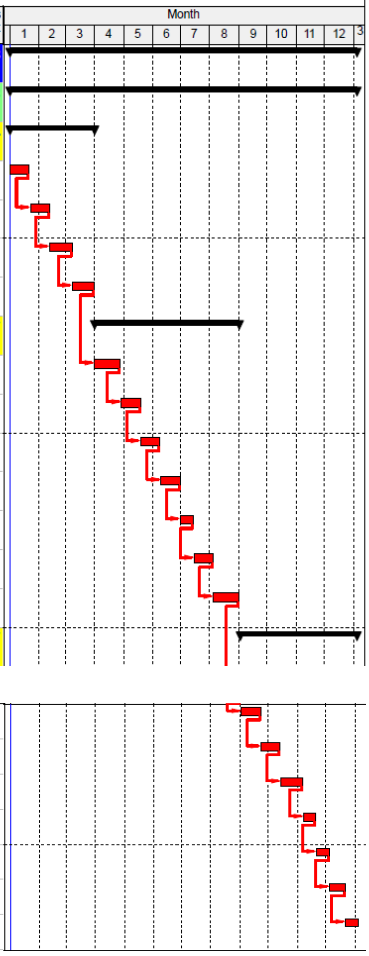
Primavera P6 can produce multiple reports to give complete idea of the project status and expected completions with expected risks indications of the project, however, it has no information about the actual duration, actual cost actual resources required for each activity because it is used to be calculated and loaded in P6 by the project team from their skill and experience. The effective use of value stream mapping can enable the project team to get the very precise cost, duration and resources of the project activities.

It has been agreed by almost all research studies on the subject of process improvement that it is not possible the a permanent and 100% improved and waste less process can be achieved on certain attempts, however, the quality and effectiveness improvement is in fact a continual process and Primavera P6 will help us every time for the effective review and update of the baseline developed for our prototype based tendering process.

3.5.1 time baseline of existing process

Projects Existing Process Vs. Modified Process after appling the prototype system for the new projects
(Initiation To NTP)

Activity ID	Activity Name	Working Duration	Start	Finish	Process Count
	Project's Process for new projects	369	01-Jan-19	04-Jan-20	18
	Existing Process before Prototype	369	01-Jan-19	04-Jan-20	18
	Initiation Phase	90	01-Jan-19	31-Mar-19	4
E1000	Initial Concept	21	01-Jan-19	21-Jan-19	1
E1010	Initial Approvals	21	22-Jan-19	11-Feb-19	1
E1020	Data Collection	24	12-Feb-19	07-Mar-19	1
E1030	Budget Availability	24	08-Mar-19	31-Mar-19	1
	Design Phase	154	01-Apr-19	01-Sep-19	7
E1040	Data Collection	28	01-Apr-19	28-Apr-19	1
E1050	Sketch Design	21	29-Apr-19	19-May-19	1
E1060	Sketch Approvals	21	20-May-19	09-Jun-19	1
E1070	Budget Estimation	21	10-Jun-19	30-Jun-19	1
E1080	Budget Approvals	14	01-Jul-19	14-Jul-19	1
E1090	Design Details	21	15-Jul-19	04-Aug-19	1
E1100	Final Design	28	05-Aug-19	01-Sep-19	1
	Tendering Phase	125	02-Sep-19	04-Jan-20	7
E1110	Tender Drawings	21	02-Sep-19	22-Sep-19	1
E1120	Bill of Quantities	21	23-Sep-19	13-Oct-19	1
E1130	Tender Documents	24	14-Oct-19	06-Nov-19	1
E1140	Did Solicitation	14	07-Nov-19	20-Nov-19	1
E1150	Bidding Process	14	21-Nov-19	04-Dec-19	1
E1160	Bid Evaluation	17	05-Dec-19	21-Dec-19	1
E1170	Contract Signature	14	22-Dec-19	04-Jan-20	1



Remaining Level of Effort — Actual Level of Effort — Actual Work — Remaining Work — Critical Remain... — Milestone

Page 2 of 2

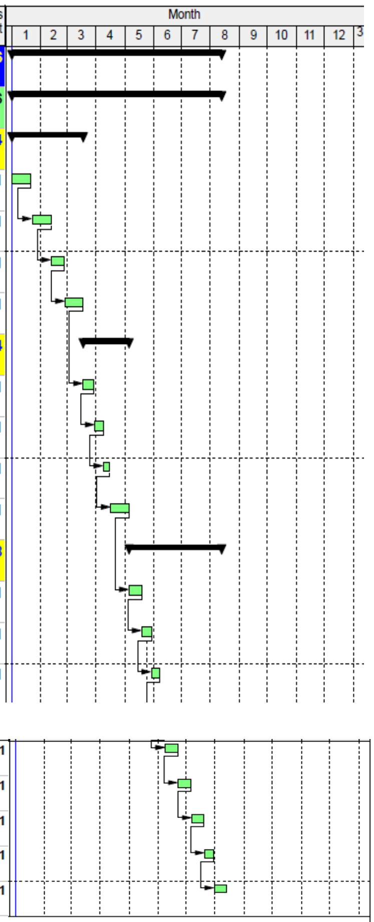
TASK filter: By Process .

Figure 23 time baseline of existing tendering process

3.5.2 time baseline of modified process

Projects Existing Process Vs. Modified Process after appling the prototype system for the new projects
(Initiation To NTP)

Activity ID	Activity Name	Working Duration	Start	Finish	Process Count
Project's Process for new projects		225	01-Jan-19	13-Aug-19	16
Modified Process after Prototype		225	01-Jan-19	13-Aug-19	16
Initiation Phase		76	01-Jan-19	17-Mar-19	4
M1180	Initial Concept	21	01-Jan-19	21-Jan-19	1
M1190	Initial Approvals	21	22-Jan-19	11-Feb-19	1
M1200	Data Collection	14	12-Feb-19	25-Feb-19	1
M1210	Budget Availability	20	26-Feb-19	17-Mar-19	1
Design Phase		49	18-Mar-19	05-May-19	4
M1220	Prototype Selection	12	18-Mar-19	29-Mar-19	1
M1230	Data Collection	10	30-Mar-19	08-Apr-19	1
M1240	Budget Estimation	7	09-Apr-19	15-Apr-19	1
M1250	Budget Approvals	20	16-Apr-19	05-May-19	1
Tendering Phase		100	06-May-19	13-Aug-19	8
M1260	Tender Drawings	14	06-May-19	19-May-19	1
M1270	Bill of Quantities	10	20-May-19	29-May-19	1
M1275	Specifications	10	30-May-19	08-Jun-19	1
M1280	Tender Documents	14	09-Jun-19	22-Jun-19	1
M1290	Did Solicitation	14	23-Jun-19	06-Jul-19	1
M1300	Bidding Process	14	07-Jul-19	20-Jul-19	1
M1310	Bid Evaluation	10	21-Jul-19	30-Jul-19	1
M1320	Contract Signature	14	31-Jul-19	13-Aug-19	1



Remaining Level of Effort · Actual Level of Effort · Actual Work · Remaining Work · Critical Remain... · Milestone

Page 2 of 2

TASK filter: By Process .

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Figure 24 time baseline of modified tendering process

3.5.3 summary of improvements

The overall impact of the prototype design model implementation can be seen in the following table 3, showing a considerable time reduction in the design phase which is the most time-consuming phase of the existing process.

Table 3

Savings due to Prototype Design Implementation.

Process	Existing	Modified	Savings	Savings
Planning	90 man-days	76 man-days	14 man-days	15.5%
Designing	154 man-days	49 man-days	105 man-days	68.2%
Tendering	125 man-days	100 man-days	25 man-days	20.0%
TOTALs	369 man-days	225 man-days	144 man-days	39.0%

3.5.4 Total waste reduction in tendering process

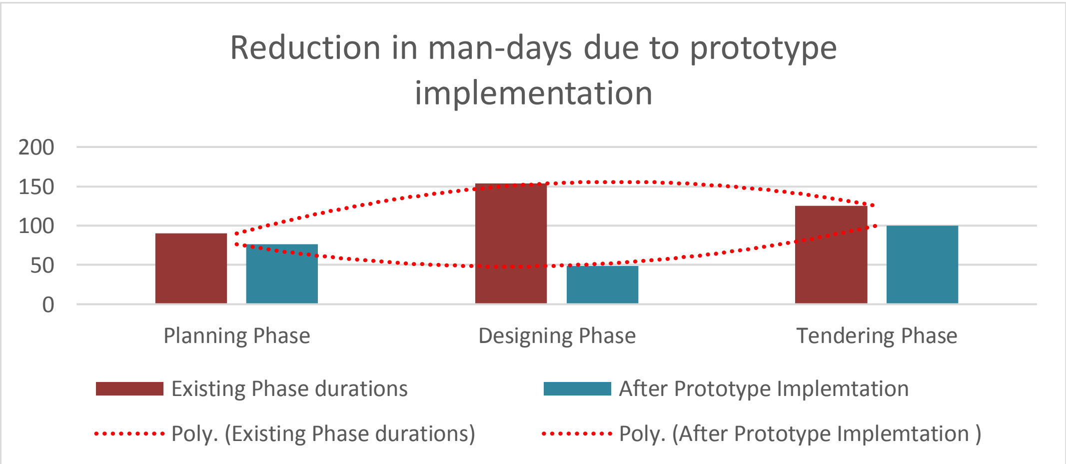

Figure 25 overall improvement with prototype implementation

CHAPTER 4: EFFECTIVE PROTOTYPE DESIGN PROCESS

In the context of this chapter the research will discuss its third goal, achieving the highest possible Value/Quality index to estimate and fit the allocated budget, especially with the increasing of complexity in the contemporary governmental buildings.

Accordingly, the modern management approaches become mandatory to achieve its goals in terms of time, quality and cost**.**

As a modern management approaches, both concepts of “6 Sigma” and “value engineering”, have succeeded in solving many of projects problems, especially high cost and delay, in addition to raising the quality to achieve client's goals. As a matter of fact, both two approaches are complementing the aimed results of the project according to customer requirements and satisfaction.

As introduced in the previous chapters, the application of Six Sigma tools has succeeded in achieving improved process with a significant savings in time and coast.

Also conceded the Value Engineering (VE), which is one of the most effective methodologies that work on improving three main areas, which are building efficiency, quality and enhancing life cycle costs of the project.

Since the research problem and concerns are including the uncontrolled budget due to the current process, and its product, which is identified as variation orders to the building design, a pre-value engineered prototype concept has been introduced in the previous chapters.

According to the research approach, Value Engineering Methodology can get its maximum benefits by its early involvement. It should be applied to the Prototype to assure its effectiveness to the owner and end-user, especially in terms of functionality and Life Cycle Cost (LCC). Also, VE tools can be used during the process of stage 2 to validate the outputs of the design process.

In this regard, the research will take the advantage of using the recommended VE Tools in the workshop phase as a tool that help the teamwork in data analysis and decision-making.

1 Strategy:

- Research follows the literature review method in identifying VE methodology, and VETs concepts and its usages, (in chapter 2).
- Research follows the analytical review method in usages of recommending VETs in the prototype design process.

2 Value Engineering Methodology Goals and Delivery:

VE study has three main phases, preparation phase, workshop phase and application & follow-up.

Each phase's output is the input for the next phase, the following figure no. (1) Shows the main steps for each phase.

Table 4

The VE Study Phases and its Steps; *Source: SALEM H, 2006*

1- Study preparation	**2- Work shop**	**3- Application & follow up**
- Teamwork selection - Coordination - Preparation of initial information. - Preparing action plan	- Data collection - Functions analyses - Ideas generation - Evaluation & selection - Searching & development. - Proposals Presentation.	- **Application plan** - **Execution follow up**

4.1 Phase one: Study Preparation

Study preparation phase aims to form the team, collect the required data, and prepare the study equipment & tools; which will be used in the next phases.

(Oshaiesh, 1997.

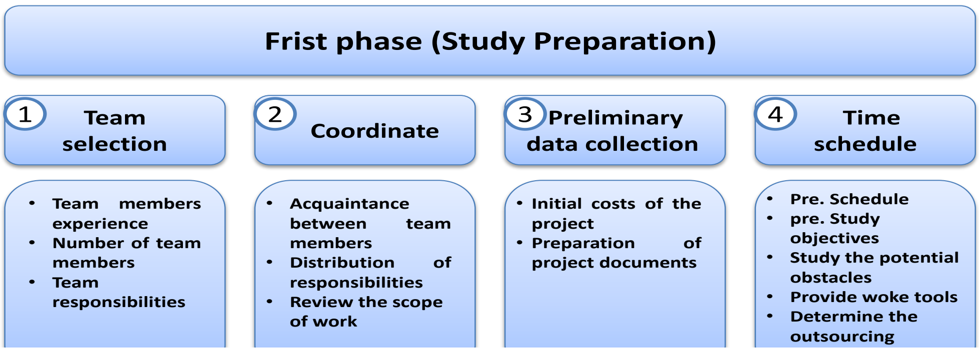

Figure 26; Study Preparation Phase; Source: VE Workshop, 2008

Workshop phase aims to activate the collaborative work between the team members to generate powerful ideas to be evaluated as solutions and proposals to increase the quality and eliminate unnecessary cost, it consists of six steps. (Alyoussfy, 2009)

The following Figure 27 Shows the steps for the Workshop phase.

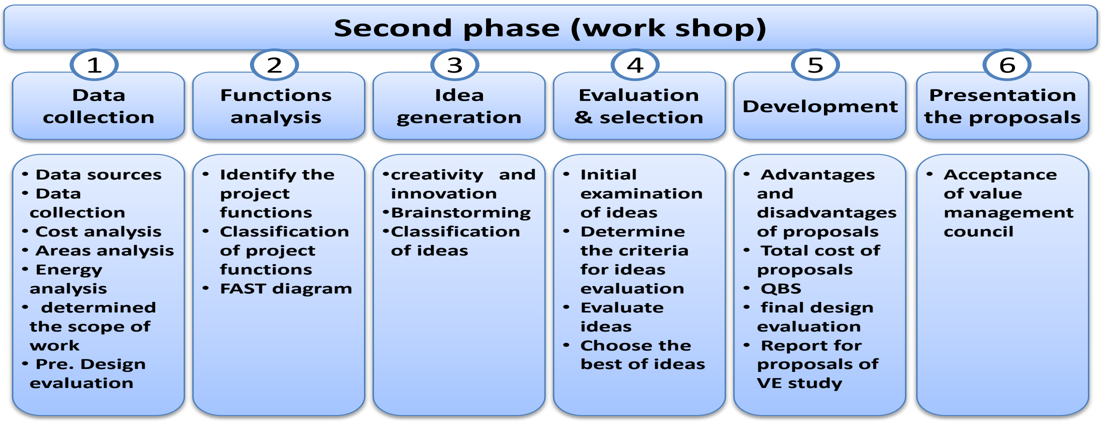

Figure 27; Work shop Phase Step (3): The Steps/Workshop phase.

After the approval of the study proposals by Value Management Council, the proposals will be present to the owner or beneficiary to persuade them. (Khwater, 2004)

The objectives of this phase are as the following:

- Develop practical action plan to ensure the implementation of the recommendations and alternatives of the VE study. (Value management, 2014)
- Follow up and monitoring the implementation of approved action plane for recommendations and alternatives.
- Write a report about lessons learnt of VE study phases. (ALYOUSSFY A.,2009)

Extracting from the literature review chapter, below are summary of VETs, its usage and category. Based on this classification each of them can be used according the design situation throughout the development of the prototype design process. VETs are falling under the following main categories:

- Problems causes Analysis tools,
- Ideas generations tools,
- Evaluation tools,
- Analytical tools,
- Selection tools.

4.2 Prototype Design Process

In this part the research will discuss the development of prototype as a base of improving the process and controlling the budget. It will focus on its qualities in terms of functionality and Total cost (LCC). VETs will be integrated in the prototype design process.

The design process will go through, its standard process, as Pre-concept, Concept, Schematic Design, Detailed Design and Tender Documents, using the Value Engineering Tools to justify two main pillars.

- Prototype Functions quality,
- Prototype Budget and Total Cost (Life Cycle Cost).

The prototype development and implementation committee shall conduct surveys, interviews and Analyse the existing buildings under the use of different groups. Top 3 best functioning buildings shall be selected from the list of existing buildings.

A brain storming sessions and workshops shall be conducted with each group, as End-user representative, to discuss the pros and cons of the top 3 best functioning buildings under their theme considering functions and total cost.

During the brainstorming workshop, with attendance of the end-user, the team leader to explain the building functions using FAST diagram, Quality Diagram and Area Analysis forms. Team leader to help the end-user and design team to have the same functions understanding by issuing such the following queries asking the end-user.

- Did his requirements/functions changed from before.
- Does he know the advantage and disadvantage of the existing building?

Is there any facilities or functions that are not satisfying him?

- Does he consider the future extension as an advantage?
- Also, team leader identifies the quality aspects like performance, constructability, maintenance, safety, circulation, flexibility … etc.

The cost will be presented as total cost. As Value Engineering is considering the cost based on the building Life Cycle Cost Analysis (LCCA). LCCA is a process of evaluating the economic performance of a building over its entire life.

The goal for of this consideration shall be for the proper selection of one design with the best possible Functions and Cost (LCC) to be the base-design, as it will be explained further in of the Prototype design.

4.3 Life Cycle Cost (LCC) and Function Analysis (FA) for Prototype Design Process

Life Cycle Cost (LCC) and Function Studies (FA) shall be considered during Prototype Design Phases (PDP). Function analysis and total cost adds two major activities to the Prototype Process Design, as operational and maintenance cost considerations and comparisons. All of these factors are considered during related phases in (PDP), along with parallel teams' achievements during design stages.

For example, during the pre-concept and concept phases of the PDP and based on database of past similar projects, the team leader establishes a "Benchmark Budget" with planning and execution budget estimates, simultaneously the team will also prepare an O & M baselines from current buildings operation and maintenance data associated with prototype design cost.

To improve design decisions, the comparative analysis approach will be followed during the design process. For example, the design team will work on trial and error basis during different design stages, to select the best functional and economical design elements from all areas including material selections, elevations, MEP installations, fixtures, energy saving factors to come up with the best functional prototype design models producing minimum Life Cycle Cost of the buildings designed and constructed on such design models.

The areas considered during the design stages for adding more value are:

Energy utilization, Mechanical installations, Electrical installations, Building Envelope, Siting/Massing, and Structural Elements. These categories can be breakdown up to 14 LCC points of comparisons. Each specific comparison involves options for addressing the same function. The following information is for the concept clarification, however, changes in factors can be considered based on the building's functionalities, size and geological locations

Table 5

Value Engineering Comparative Study

LCCA Categories	Potential LCC Comparative Studies
Energy Utilization	1. Central cooling/heating vs Split cooling/heating units
	2. latest energy saving systems, including motion sensors, human body sensors and automatic time-based controls for the lighting operations in the buildings.
	3. Equipment options for stand-alone systems (e.g., air-cooled chillers vs. refrigerant-based direct-expansion [DX] units, …)
Mechanical Installations	4. using most reliable and energy saving options from the range of heating and cooling equipment
	5. selection of best material, pumps and networks required for effective and efficient water supply systems in the building
Electrical Installations	6. Using pure copper cables to stop energy losses in lines
	7. Fully automated lighting controls for external lights
	8. Indoor lighting controls through motion and temperature sensors.

Building Envelope	9. Glazing, day lighting, and shading options 10. Effective roof insulation can control and reduce up to 70% of room temperature. 11. Use of cavity walls and insulation materials in walls and skins of buildings.
Structural Systems	12. Selection of best suitable and environmentally friendly materials and systems for different structural elements.
Siting/Massing	13. Building orientation, sizes and number of windows, heights and sizes of spaces, number of access and stairs, size and % of circulation areas. 14. Distributions of soft and hard landscaping, % of wet areas.

The prototype designers shall decide about the priority of consideration for more effective results in making the buildings most effective and efficient to earn maximum value.

The following decision matrix in figure 26 is used to prioritize the elements of considerations and select the best possible mix with maximum results of making the design most effective and efficient.

Simple LCCA Decision Matrix

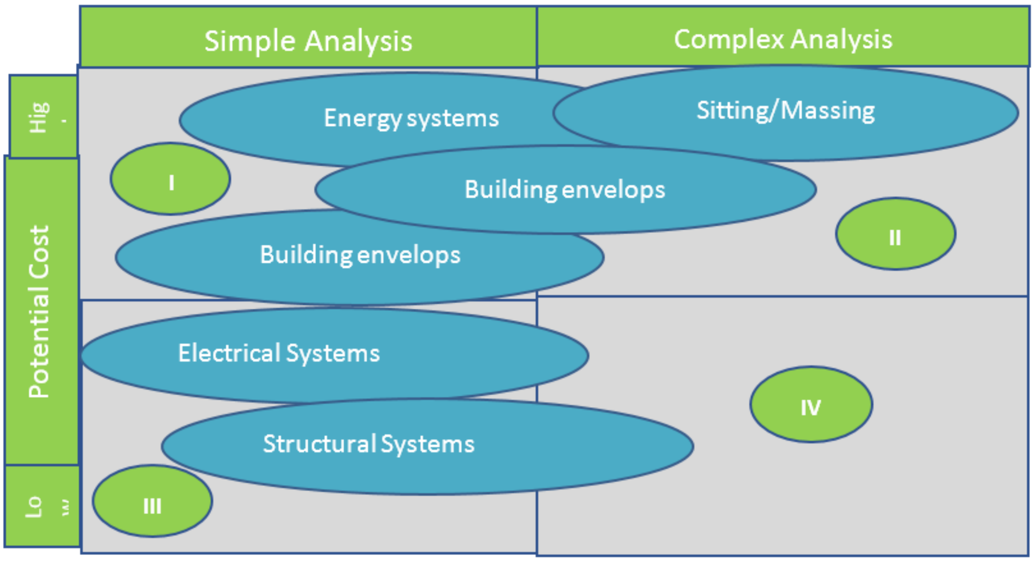

Figure 28 sample LCCA decision matrix

As shown in figure 26, the areas in (Quadrant I) shall be the top priority for consideration due to its simple analysis and high potential cost savings. Quadrant II shall be kept as next due to its complex analysis but high-cost effectiveness. Quadrant III shall be 3rd in priority as mentioned from its name due to its simple analysis and low-cost effectiveness. Quadrant IV shall be the last option to add value due to its complex process and low-cost effectiveness.

The prototype design is basically development of existing designs considering value engineering bases approach. Therefore, the process will have the analytical, comparative and selective characters utilizing the effective VE tools according to the design situation for solid decisions to the proposed alternatives.

The Project Team will decide on case to case basis after considering all factors related to the functionality and cost effectiveness during the Prototype design stages, the impacts will be evaluated by using the effective VETs according to the design situation. For example, in designing an energy efficient system, the team might decide to provide motion sensor in all corridors for light controlling so that the lighting is provided only when someone is moving in the corridor and switch automatically off if no one is passing through corridors.

The LCC and Function Analysis will give an idea about the selection of best mix of value-adding factors using the value engineering tools and techniques. LCC most effective elements along with the sustainability factors always remain the top priorities of the prototype design team.

The Prototype Design Process (PDP) will follow the standard of – Pre-Concept (Scope definition, Feasibility calculation), Concept (planning), Sketch Design, Detail designing, Construction and Authority approvals. The prototype design process will pass through the following stages during different phases as shown in following

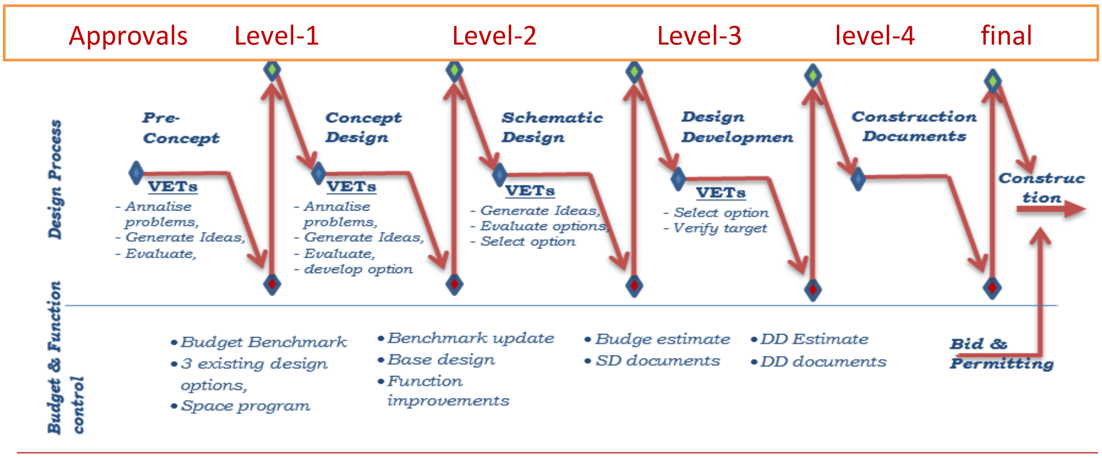

Figure 29 heartbeat chart of prototype approval process

4.3.1 pre-concept (scoping, feasibility) phase

The overall goal during the Pre-Concept phase is introducing the best three existing buildings outlined through brain storming sessions with the end-user investigating functions and operation aspects. The LCCA goal will be reviewed by the team for O & M baselines.

Function Analysis and LCCA Objectives

- To define the prototype space program with the end-user.
- Project Management Depart. (PMD) to reconfirm O&M baselines.
- Stablish solid understanding of Functions.

Function Analysis and LCCA Deliverables

- Records of O&M Benchmark (performance of similar existing facilities, list of buildings and their O&M costs)
- Space program and FAST diagram.
- Best three existing designs reflecting the end-user preferences.

4.3.2 concept (programming) phase

During the concept phase, a recommended option to be approved by the manager and end-user as a Base Design for further development. The Project Team shall update the O&M baseline. Also, to confirm the functions in terms of categories (Basic, Secondary required, unrequired, etc.) as analyzed in FAST diagram and area analysis of the space program.

Function Analysis and LCCA Objectives:

Define function’s changes\improvements to the Base-Design option.

- PMD along with its teams will generate decision matrix to decide the importance of different design elements in context of cost effectiveness and to implement the most suitable factors.
- PM shall create an integrated database for the overall processes involved in LCCA studies.

Function Analysis and LCCA Outputs.

- Implemented processes and Decision Matrix.
- Project outputs and initial cost estimate, as well as LCCA elements details.

  All plans with recommended improved functions and areas as approved by end-user.

4.3.3 schematic design phase

It is an important stage in Prototype Design Process which defines the scope, concept design, size and functionalities of the overall project, giving final shape to the important factors of LCCA. The most effective and efficient design elements are selected by the team during the whole exercise of value engineering tools and techniques during this stage of design.

The reports of the Schematic Design deliverables, indicating state LCCA systems outcomes and alternatives that may or may not be complied in the prototype design. For future utilization, LCCA outcomes shall also attach the factors that shall be ignored during the initial design stages because of certain limitations, however, can benefit in deferent facilities according the scale and function. These outcomes let the manager to revisit the cost and scope, under effective asset over the life of the building.

Function Analysis and LCCA Objectives

- Incorporate the proposed improvements to the functions to the Base-Design.
- Revise and evaluate the decision matrix and find further improvement in the factors and decision effectiveness.
- Update LCCA outcomes in compliance with regulations and codes.
- Evaluate outcomes and choose proper systems LCCA for implementation in the prototype.

Function Analysis and LCCA Outputs:

- Final LCCA process outputs tinted previous LCCA studies results.
- Reports of LCCA compliance or noncompliance in the prototype design model supported by reasons of compliances or non-compliances.
- Revised cost estimates, with life cycle cost analysis and impacts to functions improvement.

- Generate schematic prototype design DWGs and Specs documents

4.3.4 design development phase

This phase includes further detail design of the approved concept design of the prototype to clarify more aspect of the project functionalities, installations and finishing. The Function Analysis and LCC of the systems are incorporated into the project to ensure the design quality and criteria.

Function Analysis and LCCA Objectives

- The design and specifications shall be complied to Functions and LCC analysis results.

Function Analysis and LCCA Deliverables

- DD documents along with Review Report of LCCA factors, for all variations and modifications during the detail design of prototype.

4.3.5 construction documents/permitting Phase

This phase deals with documentations and authority approvals, complete sets of drawings in all area including architectural, services networks, security systems and coordination network drawings duly complied with the regulations and specifications of the statutory authorities, are submitted to all concerned authorities for final approval before execution in the project.

Function Analysis and LCCA Objectives

- Project Manager will ensure that the contract documents (plans, details, and specifications) are consistent with the designs evaluated in the original LCCA and FA studies

- Project Manager will ensure that any Value Engineering (VE) options address the impact on the LCCA elements in the project

Function Analysis and LCCA Deliverables

- Construction Documents/Permitting

Prototype Design Process, Phases & objectives:

Table 6

Prototype Design Team Objectives

Design Phase	*Prototype Design team Objectives*	*tools*
Pre-Concept phase	- To define the prototype space program with the end-user. - The O&M Baseline to be verified. - Functions understanding to be achieved.	VET's
Concept phase	- Define the Base-Design function's changes\improvements. - To generate a specific project Decision Matrix to define the most effective and efficient LCCA procedures.	VET's
Schematic Design	- Incorporate the proposed improvements to the functions to the Base-Design. - Selection of most effective system review by revising the decision matrix of LCCA.	VET's

	- Update LCCA results in compliance with regulations and codes. - Evaluate outputs to short list proper systems LCCA for effective implementation in prototype design model.	
Design Development phase	Strictly comply the design and specifications with the Functions and LCCA	VET's
Construction Documents Phase	Confirm Value Engineering decisions from the early design stages with the Functions and LCC.	VET's

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

The impact of prototype implementation over the cost of tendering process as well as on the life cycle cost (LCC) of the complete project is directly proportional and results in outstanding savings in the very important triple constraints of the any project. The concept of prototyping the design model is not new and it has already been in use around the globe especially for the buildings whose functionality is pre-defined and there is no change in their functionality due to the change in its geological location.

Therefore, this master project has been initiated to explain the benefits of prototype design model implementation in repetitive projects with all its factors and show its ultimate benefits of adding values and removing wastes from all important factors of time, cost and scope as well as keeping Quality of the output at the maximum possible level.

As concluded in table no. 3 page 56, an outstanding reduction in the time consumption on the tendering process of repetitive buildings with the implementation of the prototype design models is found.

The existing process completes in 369 man-days of 8 hours each day, however, it dropped to only 225 man-days after the implementation of the prototype design model which is about 39% reduction in the overall time duration of the existing tendering process.

The baseline is prepared showing all kind of impacts at different levels of the tendering process producing different graphs and charts to follow up precisely and use it as a control tools during the progress of the tendering. As primavera P-6 professional break down the whole process in manageable parts or activities with each activity actual time and cost-plus resources, however, to investigate the time and cost correctness we applied value steam mapping because Primavera does not give any idea about the improvement in the activity level savings in time and cost.

Main source of above time saving is the clarity of scope and effective processes with minimum wastage of time at the activity levels. Due to the effective implementation of value stream mapping almost all wastes present in the existing tendering process has been encountered and eliminated.

Further improvement has been brought in the existing tendering process with the help of value engineering tools implementation by increasing the quality of the output without increase in its cost and time resulting in the high level of end-user satisfaction.

The time been wasted in all operational project maintenance and operations has also been greatly reduced due to the effective and efficient designs after a trial and error process in different operational projects.

5.1 Impact on the Cost of Project

There shall be no or minimum cost at all the processes related to the tendering of repetitive buildings like concept design, detail design, authority approvals, budget estimation and approval process, tendering documentations, Tenderers inquiries and clarifications, end user requirements accommodation and understanding which an immediate and direct saving is due to the implementation of the prototype design models.

5.1.1 cost savings due to well-defined scope.

According to the existing tendering process, the scope of repetitive buildings is not defined at the tendering stage as most of the projects are tendered under the design and bid format. The tenderers are not aware about the final approval and actual requirements of the client due to which they quote high prices in bidding to indemnify themselves against the risk of expected high specification and material demands from the client or any other design complications resulting in delaying and extra cost.

5.1.2 cost savings due to minimum variations

In most of the project the cost and time are badly affected by the scope variations, it is one of the major sources of project over budgeting and delaying as well as give birth to conflicts and tensions in deciding the requirements of end user included in scope of the contractor or not.

The effective and agreed prototype can minimize the risks of variations due to additional requirements by the client because all stakeholder do know their scope and there is no or very minor ambiguities in the contract documents regarding the scope of the contract and it is very easy to decide any additional requirement if it is included in the scope or shall be claimed as variation.

5.1.3 cost savings due to minimum design errors

Another source of variation is a design errors and omissions, as it is not possible to produce errorless design so there is always a high risk of design error which also leads to the additional cost and time due to claims of variations, however, this also can be easily handled and mitigate it greatly with the implementation of the prototype design implementation because the design is actually based on the physically existing and functional building and most of the stake holders do know minor and major design elements from the existing prototype design models.

5.1.4 cost savings due to effective use of Resources

Prototype design model comes in existence after a long exercise of trial and error for each process involved in the whole system of project initiation until its execution and operations. During the implementation of different tools like value stream mapping and value engineering it is used to be double checked that all processes from minor level to the very macro have transformed to the most effective and efficient processes to the maximum level of possibility.

By an effective and efficient processes, we mean that the resources usage has been brought to the level close to precision, which means that maximum possible output has been produce with the use of minimum required resources that happens only with the enhancement of the performance in the same circumstances to increase the per capita production ability.

The performance increase is achieved by effectively managing the skills and abilities and making high performance groups and teams because some employees perform more in teams rather working in isolate working environment.

5.2 Impact on the Scope of the Project

Scope definition is one of the direct purposes behind the prototype design model implementations, however, the other factors of time and cost are indirectly improved due to the effective design and scope definitions of the project.

In case we have an approved prototype, it will be the biggest source of scope definitions at any stage of the project, during the bidding if the scope is well defined and having no ambiguities which is only possible through prototype design models, the tenderers will used to go in much tough competition resulting in very competitive and less price bidding.

According to one study the expected cost saving due to well defined scope at the tendering stage shall not be less than 30% of the overall project cost, which can be easily achieved with the help of prototyping the project.

Once the project scope is effectively defined and the chances of ambiguities are minimized, it automatically cut the project cost not only at tender stage but during the execution as well by mitigating the chances of variations and claims.

5.3 Recommendations

Prototype design, in conjunction with Value Engineering Methodology during the design phases, is introducing a smart solution to control the entire budget. In addition to raising entire process efficiency and outcomes in terms of functionality and cost. Also following VE in considering the total cost to include operation and maintenance, and involvement of end-user during the design process, progressively, consolidate the design decisions.

5.3.1 end-user's role in prototype design.

The End-User effective involvement and inputs throughout the design stages of prototype models is the real key to get the most sustainable and effective prototype design models. The information provided by the end-user regarding the required functionality can be considered the baseline for the concept development of the required prototype design models.

5.3.1.1 *at concept design stage*:

End-User shall suggest three best existing buildings with respect to their functionality and maintenance, in addition to that, the weakness in the design and construction of the selected 3 buildings shall also be provided by the End-

User. Based on this information, the design team shall produce a concept of the proposed prototype and shall submit to End-User.

5.3.1.2 at detail design stage.

After getting the concept design approval from end-user, the detail design works shall be started, keeping in view the end-user's initial comments regarding the weaknesses in the existing best functioning buildings, all errors and design faults shall be addressed, and improved designs works shall be done to mitigate the issues been raised by End-user in the subject buildings. For example, if the end-user was not happy with the parking facilities of the selected buildings, then their comments shall be considered during the infrastructure design of the prototype design models.

5.3.1.3 at the value engineering stage.

At the value engineering tools application, once again the input of end-user ranks no.1 due to their information based on the practical experience and not on the assumptions only. For example, the value engineering is talking about the reduction in the Life Cycle Cost (LCC), the end-user can provide the most important information regarding the functional and operational cost of the selected buildings, the issues they have been faced in the maintenance of existing projects, the design faults resulting in producing regular faults and increase in the maintenance costs. The utility bills its consumptions information for the selected buildings can provide valuable input data for the implementation of value engineering tools and technique more effectively.

5.3.2 recommendation for prototype implementation.

- One of the existing best functional building shall be taken as baseline of each repetitive building prototype design model preparation.
- VE tools shall be applied to improve the baseline design up to the maximum possible level by involving all stake holders and end-user of the subject buildings.
- The study models and animated models including BIM shall be prepared and presented again to all stake holders for further comments and acceptance.
- The first project based on the prototype shall be considered as part of the prototype testing phase to develop the real-world sample of the approved prototype model.
- All latest requirements of green building shall be respected in the subject prototype design to protect the environment and save energy for the generation to come.
- The prototype design shall be environment friendly and shall protect the lives of its users and visitor in case of any emergency during its life time cycle.
- The prototype design models shall not only improve the functionality of the buildings but shall also reduce the life cycle cost by minimizing the maintenance costs.

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