Scope Management

by

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Submitted to the Department of Civil and Environmental Engineering
in partial fulfillment of the requirements for the degree of

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Abstract

This thesis presents the concept of scope management pertaining to industrial and mega construction projects . It describes the causes for changes in scope, which are usually due to a faulty process of scope development, i.e in-complete scope definition, and scope modifications. Various Players in the construction process contribute to and channel these changes, the most important being the owner and designers and the interface between them. The main finding is that if the factors that contribute to the decision making process of the owner are rightly directed, and the interface between the designers and owner properly managed, a major portion of scope management has been effected. Some other aspects of scope management, notably management of construction inputs and external influences of regulatory and public agencies, are also discussed.

Thesis Supervisor: Robert D. Logcher
Title: Professor

Acknowledgments

I would like, first and foremost, to express my sincere thanks and gratitude to Professor Robert D. Logcher, *for his invaluable advice and guidance.*

I would like to thank the government of Pakistan for its financial support.

I would also like to thank all my teachers who taught me.

Dedication

To my family

My Parents*; For their love and attention, and showing me in their own subtle ways how to aim for the stars.*

My Wife*; For showing me the lovelier and lighter side of life, for her patience and love and all that she has done for me.*

My Sisters*; For their love, support and guidance.*

My Children*; For cheering me up and giving me hope with their smiles whenever I was fed up with life.*

My In-laws*; For their love and support.*

My Friends*; For their love and support.*

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Chapter 1

Introduction

1.1 Purpose

This thesis presents the concept of scope management. The purpose of the thesis is to search for the reasons for scope changes and to come up with some recommendations for the management of scope.

1.1.1 The Need

The need for this is demonstrated by cost and time overruns in the original budget and the schedule of the projects caused by change in the original contemplated scopes. For example in mega-projects like the Euro-Tunnel[1], Boston Central Artery/ Tunnel[2], and Boston Harbor Sewage Treatment Project[3]. A slight change in the scope of work, for whatever reason, can cause a change in the scope of the project. Which would be of the order of millions of dollars, or for that matter in any Mega project, which by definition are projects costing over a billion dollars. Here it should be noted that increase in the cost due to change of scope must be differentiated from cost overruns which occur due to delays or unit/lumpsum change in the costs of construction.The recommendations reached in this thesis are based on the analysis of the process through which the scope

[1]The tunnel under the British channel connecting France and Britain
[2]The Depressing of the interstate I-93 and extension of I-90 Boston U.S.A
[3]The construction of sewage and sludge treatment plant at deer island Boston U.S.A

of a project is developed.

1.2 What Is Scope

The scope of a project can be be defined in terms of the functionality which the project is intended to provide, attain, or span. A project scope statement defines, in writing, drawings and price figures, the intended span of work expected and to be provided for in plans for a new facility. The scope statement should also spell out expectations about any eventual extensions, and should include a contingency policy as well. The scope statement should be a clear communication of the extent and functionality of the facility, between the proposers, sponsors, designers, constructors and the users or purchasers. In order to be explicit as to the meaning or extent of various systems, scope may be further described in terms of cost budget figures. Such budget figures need to be expressed in enough detail to provide the basis for a cost control system and for evaluating any subsequent changes to that scope. According to Frederick [6], a technical scope document is what describes the projects's physical characteristics, establishes the design basis, and provides input to civil-structural, architectural, plant design, mechanical,electrical, and control systems disciplines.

Elements usually employed to produce this definition include P&IDs[4], single line diagrams, facility layout sketches, an equipment and instrument list, bulk take offs of mechanical/electrical quantity items, an engineering procurement, instrumentation and construction master schedule, a written controls philosophy, and repair standards expected. Minimum results expected from the production of a project scope statement include a broad description of what is to be covered in the works.

The scope of a project can conceptualized to be as shown in Figure 1-1 .The overall scope of the project can be thought of as a composition of scope of units which in turn are composed of scope of subunits and so on. The functionality of sub-units determine the functionality of the unit and similarly the combined functionality of the units determine the overall functionality.

[4]piping and instrumentation diagrams i.e in case of petrochemical plants

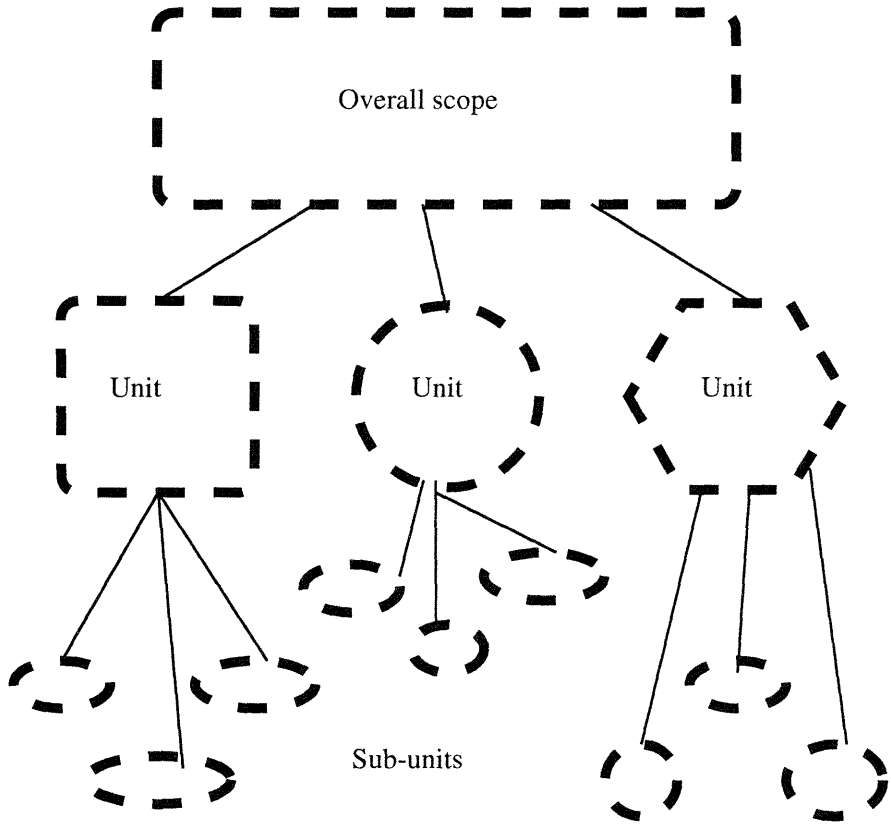

Figure 1-1: Scope Definition

From Figure 1-1 coverage of scope can be considered in two directions; Horizontal and Vertical. Horizontal scope can be thought as the cumulative coverage of units or subunits at the same level of detail whereas vertical scope is the completeness of scope of the respective units and subunits. Horizontal scope is said to be well defined if all units are defined and similarly vertical scope is well defined when all the subunits and detail of their components are well defined. The purpose of this distinction as we shall see in chapter 3 and 4 is to determine which type of change has more impact and which is more frequent, which shall help us to determine how deal with them and where to focus our attention at a specific stage in the project.

1.2.1 Scope Changes

Any change, at any stage, in the functionality of the project or facility is termed a scope change. All other changes which result from design errors and omissions, acts of god, or changed conditions are classified as refinements or alterations. Overruns resulting from alterations, refinements and cost escaltions are independent of scope changes. The change in functionality can be of three types and can be in the horizontal or vertical direction as described in section 1.2.

- Change in the capacity of functionality
- Change in the quality of functionality
- Complete change in the functionality

Change in the capacity of functionality

This kind of a change can be either addition or subtraction in the span of work. The examples are increase or decrease in the length or width of the road with other specifications remaining the same, or the increase or decrease in the number of standardized housing units to be constructed.

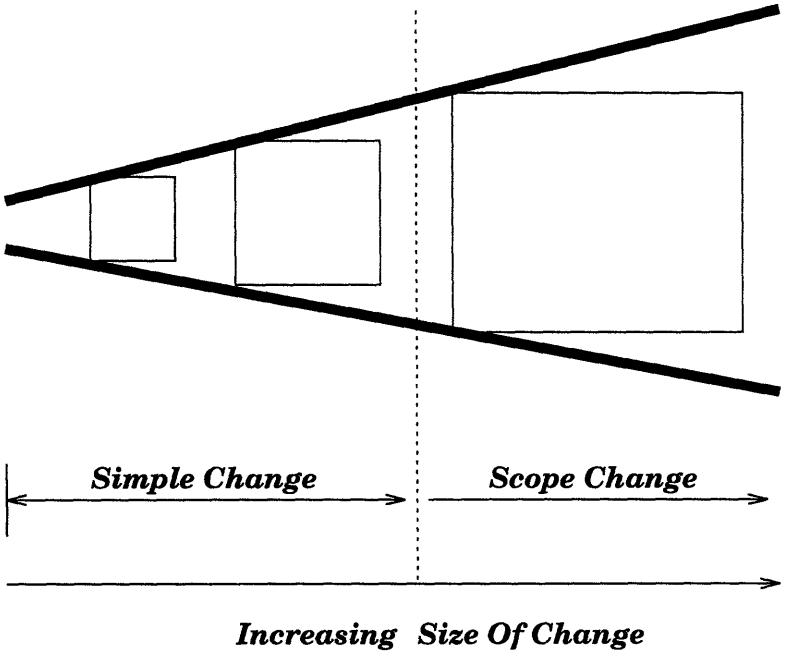

Figure 1-2: Increasing Size Of Change

Change in the quality of functionality

This kind of a change is an addition or subtraction of a functionality to the span of work, so as to change the overall functionality. The examples are providing or deleting dividers, toll booths, extra-markings and guard-rails in a road design or providing or deleting facing in a building etc.

Complete change in the functionality

This kind of a change is a complete change in the original functionality of a project or facility. The examples of such a change are changing the design of a flexible pavement to a rigid pavement, or changing the design of a building from reinforced concrete to structural steel.

There are a variety of reasons why scope changes takes place and what factors might force such changes. They are discussed in detail in chapter 3 of this thesis.

1.3 Increasing Size of Change

Sometimes if the the capacity or size of a item, activity or portion of a project is changed the functionality of that item, activity or portion does not change. But if the size is increased to such an extent that a change in functionality occurs, then it can result in scope modification. To understand this, consider for example, that a tunnel is being constructed which also has utility lines passing through it. If it so happens that there is a change in the design sizes of the utility lines. Up to a certain extent we might be able to adjust them in the same dimensions of the tunnel, but if the change is large enough the dimensions of the tunnel might have to be changed. Such a change might itself be a scope change or cause a change in scope for example, the ventilation system might need relocation and redesign, and the new design might be functionally different from the previous one. Figure 1-2 depicts such increasing size of change, the dotted line is the critical point where the change becomes a change in functionality and hence a change in scope. In some cases the reverse of this might also be true, that is with a decrease in size the functionality might change.

The importance of this discussion is that this type of change in functionality can happen unintentionally with incremental approval of increase in the size of an item, with the assumption that it would not cause a scope change. Such a scope change might be due to the activity itself or due to its disruptive or radiating effect on other dependent or related activities. So it is important to watch out for this kind of changes that do not appear to be a scope change in the beginning, but can become a cause of one. It is important to keep track of the border line point, whence the change becomes effectively a change in the functionality and consequently a change in the scope. It should also be noted that the border line point is different for different items and also unique for different cases.

1.4 Increasing Type Of Change

This is similar to the increasing size of change as shown in the Figure 1-3 on page 14 with the difference that this is the change is in the type of the activity or item. Upto a certain point, the change in the type does not result in the change in the

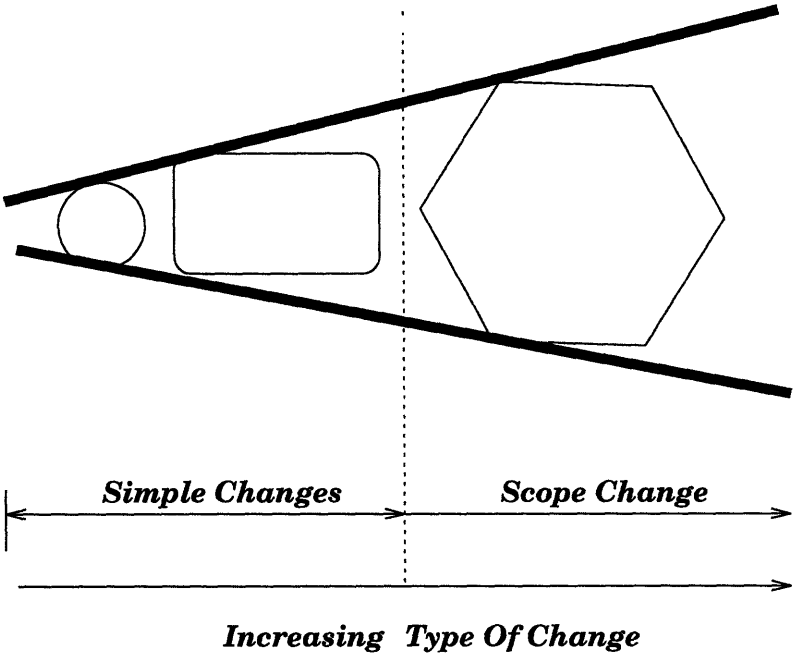

Figure 1-3: Increasing Type Of Change

functionality, but a critical point might be reached after which a slight change may cause a change in the functionality. It should be noted that change in functionality due to the change in the size or type is dependent on the nature of item and differs from case to case. In some cases/items only a slight change might cause a change in the functionality and in others it might not be readily apparent. Example of a critical change would be a change in the type of lining of a pipe in a chemical plant and of a not so readily apparent change the change in the diameter of the pipe.

A simple explanation of both this examples is that both of them can cause change in the functionality in the first case a very corrosive fluid might not be permitted to flow and in the other a change in the pressure or velocity might not be permissible.

The object of describing these two types of change is that, mistakes in size and type of functionality are the most latent kind of faults, can happen in both the first two phases of the construction process, and the scope change can occur during the rectification of these faults and hence can happen unintentionally.

1.5 Objectives Of The Thesis

The objective of the thesis is to

- Analyze The Construction Process
- Determine The Causes of Scope Changes
- Recommend Ways to Control Scope Changes

The whole analysis is done on the constituents in the construction process as shall be discussed later on. That includes the players their roles and the activities and their inputs and the stages of the process itself.

1.6 Organization Of Thesis

In the first chapter, an overview of the construction process and the project life cycle is presented, to provide a basis for reference and understanding for further discussion. In chapter two, a review of the literature on scope management is presented for the purpose of analysis and development of further discussion.

In chapter three the author's view of the problem is presented and in chapter four some ways to deal with it are presented.

1.7 An Overview Of The Construction Industry

Construction Industry is regarded as a highly fragmented industry. It is more than 1/10th of GNP of U.S.A and has a major effect on the economies of other nations also. Although standardization and mass scale production are on the rise in many areas of construction, such as residential housing, bridges, and industrial construction, it is only a very recent trend and most of the construction projects due to their initial conditions and individual needs, are one of a kind and unique in many respects.

Two of the major Characteristics of the construction project are the cost and useful life of the project. All other requirements are the result of either of these, for

example duration and quality of design are sub-characteristics of cost and life of the project respectively.

As most of the construction project happen only once, and the chances of repeating the similar type of a project under similar conditions is very low. The effectiveness of any management system, pay-back of a specific procedure, savings, or benefits of an alternate selection can seldom be accurately ascertained.

It would not be completely wrong to say that construction is a process which promotes the participation/involvement nearly of all the sections of the society. This is the one of the major reasons as to why construction is such a chaotic and unpredictable process. The causality is simple the broader the spectrum the more diversity in interests and greater number of influences from different parties.

1.7.1 Players In The Construction Process

In order to present the construction process it is necessary to identify the Players involved in the construction process. Some of the players are directly involved in the process therefore they are known as direct players, while others are indirect players. Following are the direct players in the construction process.

- The Owner
- The Designer
- The Vendor
- The Constructor
- The User

Owner

The owner is the name given to the entity who initially or ultimately owns the project. The term owner is usually understood to refer to the entity who has the final say in the decision making process. It might be a single or a multiple entity as

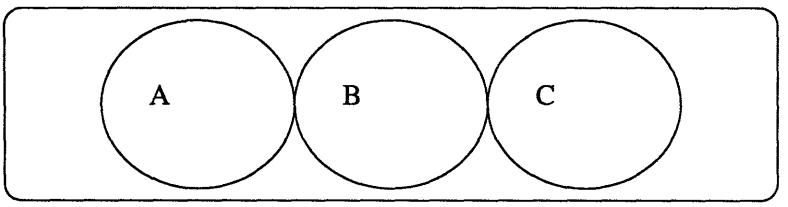

Figure 1-4: Multiple Owners

shown in Figure 1-4. An owner might range from a single enturepenure to group of developers or an organization to a congolomerate of organizations or might even be a government or in rare cases multiple governments. A good example of such a project is the Euro-tunnel project which is owned by both Britain and France.

Depending on the characteristics of a project especially the type of contract[5] the owner-ship might change hands during various time spans.

Designer

The designer is the name given to the entity who plays any part big or small in the design of the project. This includes architects, geotect consultants, structural designers, and ultimately even interior decorators. As discussed in section 1.7.1 all these can be single or multiple entities depending upon the characteristics of the project. The mentioned names are just an example; in-fact the term designer includes a whole range of consultants and specialists from a wide range of disciplines some of which are shown in Figure 1-5 on page 18 .

Vendor

Whole sale material retailers, fabricators, and Manufactures come under the umbrella of Vendors. They also can range from single person to big firms or factories. In some cases some of them come under the class of sub-contractors.

Constructor

[5]Build operate and transfer, Build and transfer, or build and operate and own etc.

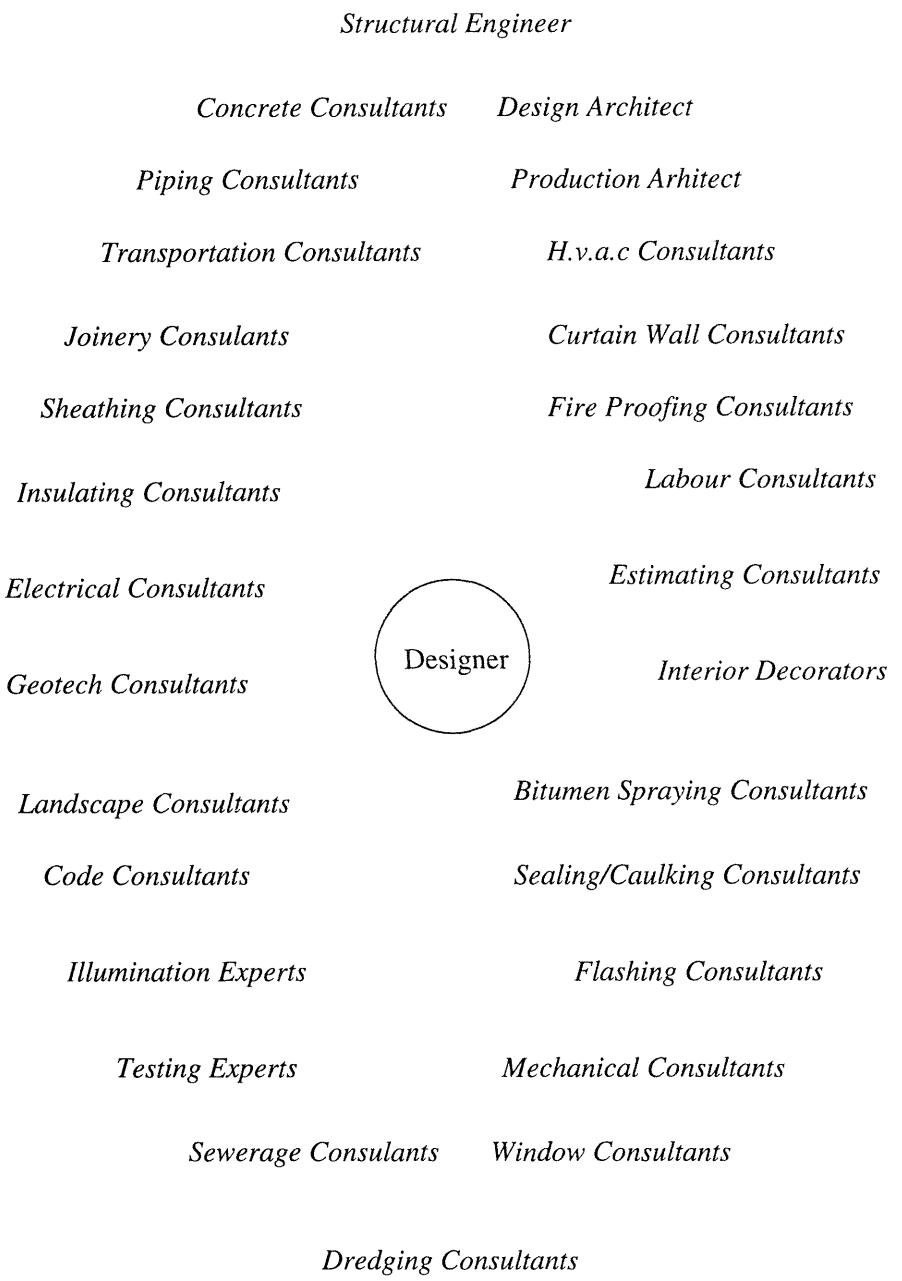

Figure 1-5: Different Design Disciplines

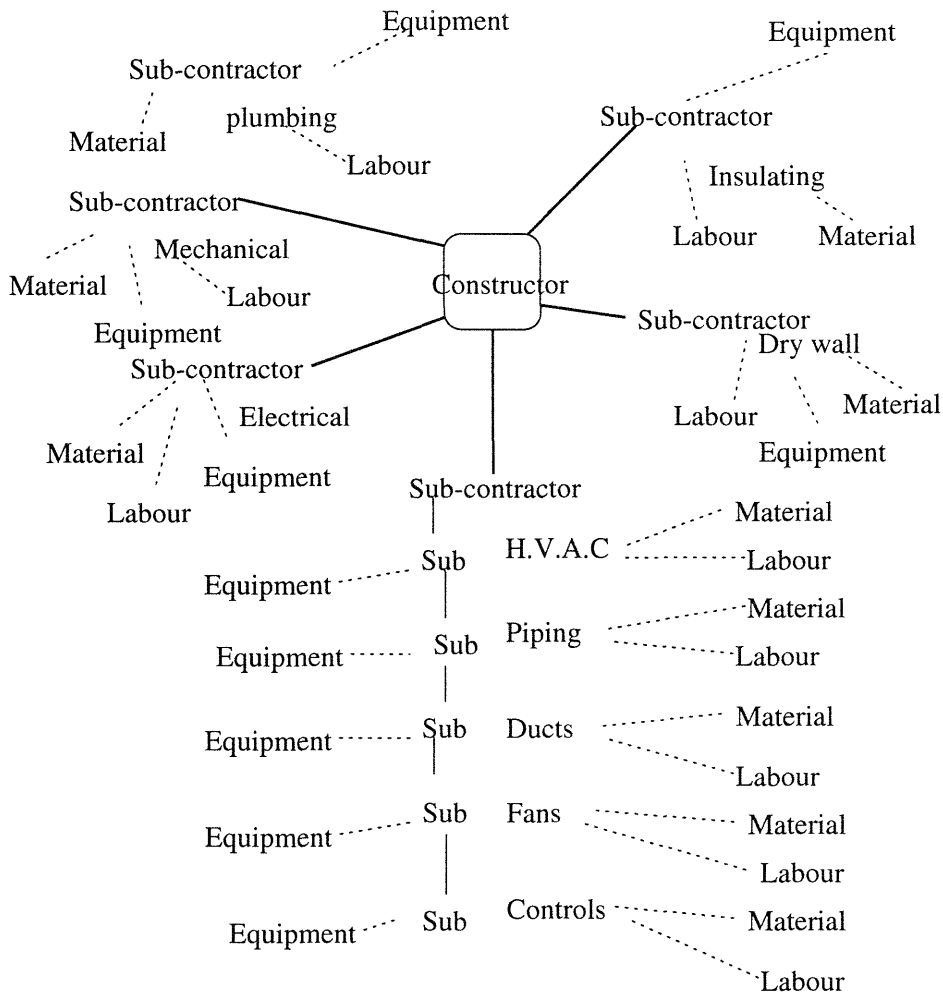

Figure 1-6: The Constructor And Vendor Relationship

They are the entity who put the pieces together acquired from the vendors, as desired by the owner and designed by the designers. They include construction managers, general contractors, and contractors.

The Figure 1-6 on page 19 shows the relationship between the vendors and the constructors. The purpose of the diagram is to show the myriad of interfaces between them, and their effect as shall be discussed later on.

User

This is the entity who will ultimately use or in some instances operate the facility. In the literature they are also referred to as operating and maintainance staff.

These are the direct players in the process. The indirect players are

- The Government
- The Public

Government

This includes all the government departments that have any influence on the project. It can range from local government bodies to the federal government. At times all the levels of government might be involved in the project. The influence of the government can be direct if it is the owner or funding the project and indirect if it is only regulating the project through permitting agencies. Another kind of involvement is when the government is the executing agency.

Public

This includes the people which are directly or indirectly affected by the project or live in the vicinity of the project. It also includes the non governmental organizations.

Now that the players have been briefly described, their interaction shall be also briefly described in the following section. So that their influences are better understood as they shall be discussed later chapters.

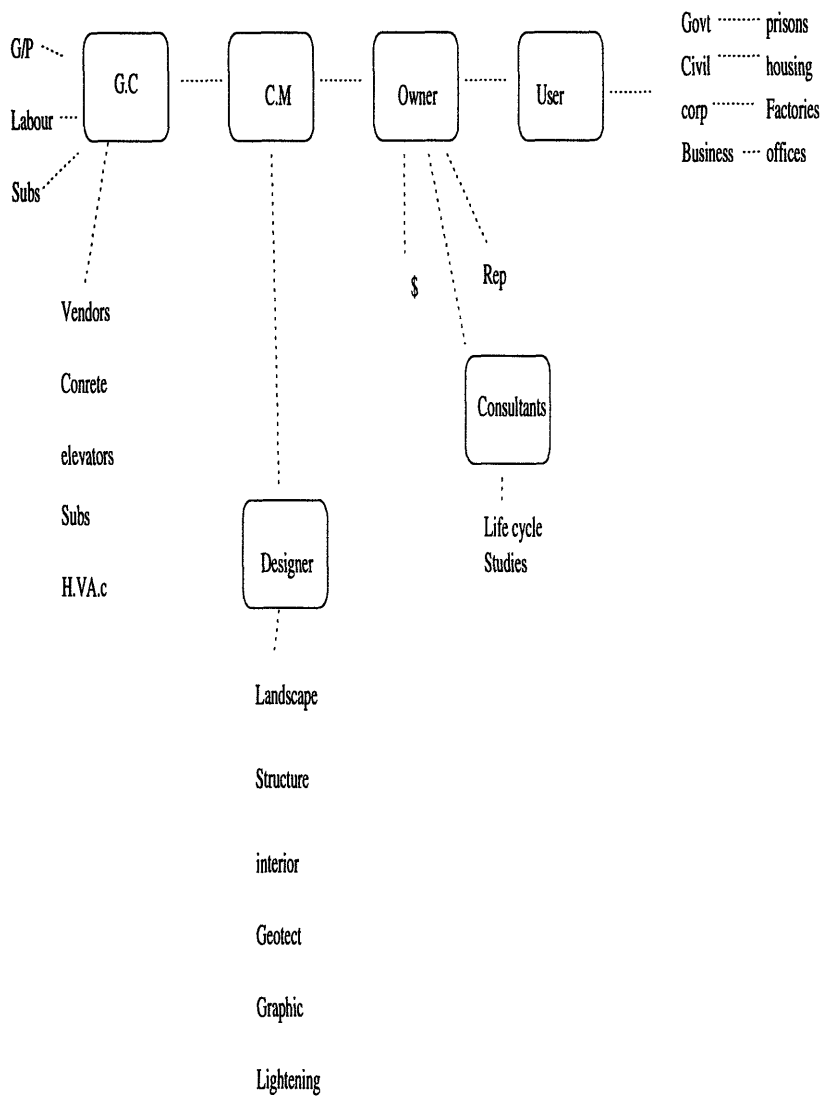

Figure 1-7: Player Interaction

1.8 Player Interaction in Construction Process

Figure 1-7 shows one of the most common arrangements of interaction between these players. Starting from the right side of the diagram we see that the users can be the government, some civil entity, a corporation or some business venture. Depending on the project and type of contract the users can be only the end users or might in some cases be owners also. In both the cases the users have a important role in the process. The present trend on construction projects is that the owner hires

a firm/firms[6] specializing in construction management. These firms or individuals are known as construction managers. This step is usually taken by the owner in the conceptual phase. Then this firm does feasibility analysis and preliminary designs in-house or by hiring consultants. All variations of these arrangements depend upon the characteristics of the project. The arrangements and the their timings are unique for a project. Another combination is to have a separate design and management firms responsible for construction and management respectively. In such a case the design firm assumes the posture of lead design engineer and hires other designers which are known as project design engineers, Section design engineers or discipline design engineers as the case may be. The lead design engineer assumes the primary responsibility for directing the design of the major project components. The lead design engineer develops design standards, prepares plans and specification at a conceptual level for all facilities. The lead design engineer also prepares a final design of those facilities requiring early completion and oversees the selected detailed designers that is the project design engineers. The detailed designs are done by project design engineers and are inculcated in the final design by the lead design engineer. This whole process is a iterative process as shall be discussed in chapter 3, and after several iterations which continually modify the design a final design is evolved.

The owner himself or through his construction managers the latter of the two being more common, infact the norm on mega projects, than hires a general contractor which does part of the construction work and mainly gets the work done through subcontactors. The construction managers in this case becomes the fulcrum point in the whole interaction. Any transfer of information has to pass through him as shown in the Figure 1-7 on page 21. This diagram is just to show one of the ways in which the different players are related.

In the following section a generic project life cycle of a typical project is presented, independent of individual structural set-ups.

[6]joint venture partners

1.9 Project Life Cycle

A project can be separated into phases, with each phase having activities grouped together to accomplish an overall objective for each project phase. The life cycle of a construction project can be thought of as consisting of five distinct, phases namely

- The conceptual phase
- The Engineering phase
- The procurement phase
- The construction phase
- The start up Phase

These phases are shown in Figure 1-8 and Figure 1-9 on page 24 and page 25 for conventional and fast-track projects respectively.

The basic reason for such a break-down of a project into phases is to implement effective project controls. The timing of implementation of effective project controls is largely the function of the nature of the project. Each of these phases can be further split in to sub-phases having their own distinct identity based on the activities performed respectively in those phases and also according to the degree of involvement of different participants/players. In other words each of these phases have their own life cycles for the purposes of project control. These functional life cycles are interrelated and certain points overlapping (Cagle [2]).

1.9.1 Conceptual Phase

This is the first Phase of any project's life cycle. In this phase a tangible form is given to an abstract idea usually conceived by the owner. In this phase preliminary studies are done which determine the technical and financial feasibility of the proposed project. Based on these feasibility studies the decision is taken by the owner whether to proceed with or abandon the project. If the project is not sound either technically

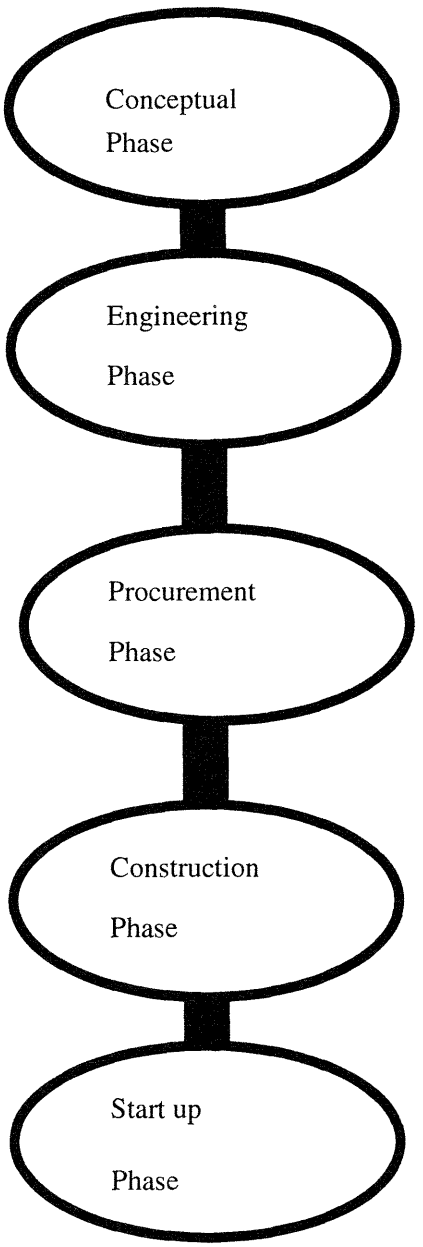

Figure 1-8: Project Life Cycle

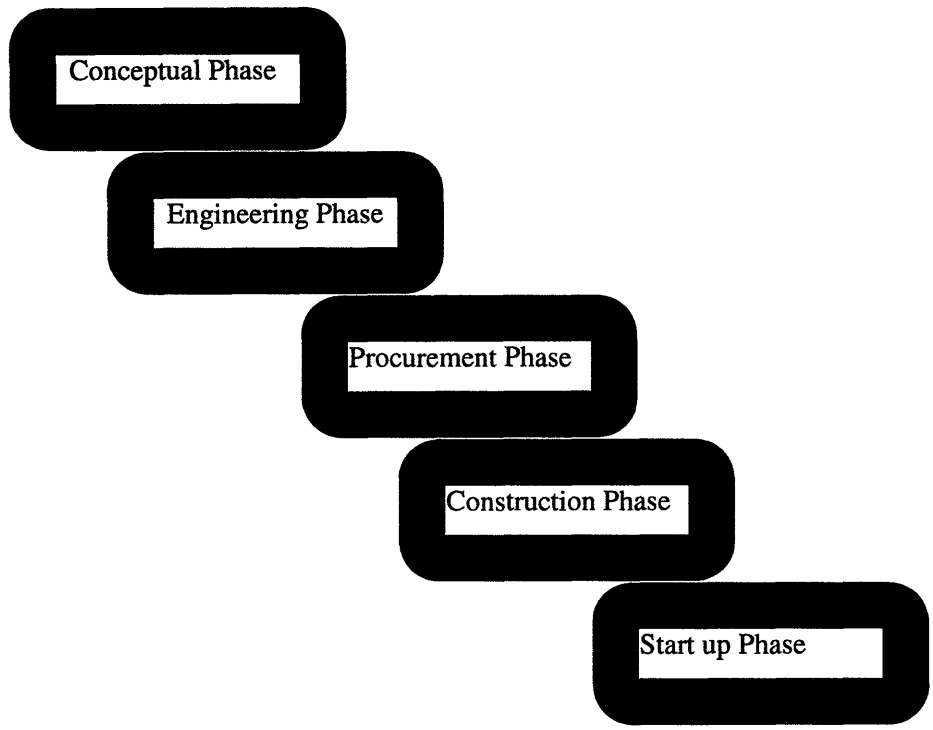

Figure 1-9: Fast Track Cycle

or financially it is good idea not to proceed any further and this is the reason why most of the projects never proceed any further inspite of millions of dollars spent in this phase. In some cases some of the money spent can be salvaged or even some profit made on it by selling the idea and the studies/feasibility analysis done in this phase.

This is the phase when the owner or a developer whichever the case may be conceives the basic idea. A point worth noting is that in this stage sometimes the owner himself is not sure as to what he really wants or where is he heading, and is usually bouncing ideas off other people specially the designers. The basic architectural drawings are prepared in this phase presenting the various alternatives. If an option is selected then other basic project initiation activities, which include selection/initiation of various other players as described in subsection 1.7.1, initial specifications, schedules, and plans are started.

So in essence in this phase, basic renderings are prepared and equipment/facility performance specifications are set. Studies are performed to select the best among

available alternatives. Some times flow diagrams, piping line list, instrument summary sheets, electrical one-line diagrams, equipment arrangements, etc. are also prepared in this phase with special instructions. Ideally procurement on long lead-time items should be initiated in this phase and plans for obtaining required licenses and permits must be made. If possible cost control accounts and breakdown structures to be used for project control should be prepared, which help in preparation of preliminary project budget. and establishing initial master project schedule to determine the overall project duration and the interrelationships between project phases.

Outside finances are usually secured after this phase based on the financial feasibility determined in this phase. The feasibility study is usually based on the conceptual estimate prepared in this phase.

1.9.2 Engineering Phase

In this phase engineering tasks that define the type and general size of the facility portions, starting from the basic units to the overall scope are determined. These tasks include the preparation of detailed architectural drawings. This phase is begun after it is determined that a proposed project is feasible.

Engineering phase includes preliminary engineering tasks that define the type and general size of basic units of which the facility is comprised. During this phase time schedules and cost estimates are developed for the detailed engineering and the subsequent phases.

An incomplete or faulty definition or incorrect selection of the items in the above can be a cause of scope change at a later stage. If the owner really knows what he wants and has a method which helps him to monitor the process. Find and correct errors if needed, the designers and consultants are less likely to make mistakes. Thus the chances of scope changes are greatly reduced.

In engineering phase technical procurement work packages, construction work packages are prepared and the "Project execution plan"is finalized. Detailed engineering schedule and construction schedule are expanded and are taken a tier below, and proper interfaces with procurement schedule are assured. Also established are

the project control cost estimate and cash flow forecasts.

In addition to all this, safety and constructibility studies are intensified and licenses and permits obtained.

1.9.3 Procurement Phase

In this phase the detailed drawings are made available or produced for all parts of the project, and purchasing of the material to construct the project is done. In this phase equipment and materials are procured and most of construction and vending contracts awarded. For this reason equipment and material specification and vendor information is made available according to already designated dates as per detailed engineering schedule. The required equipment and material items are delivered by dates designated on the construction schedule, and contractors mobilized to perform per start dates on the construction schedule.

1.9.4 Construction Phase

In this phase the facility is constructed according to work packages prepared during the detailed engineering phase using equipment and material obtained in the procurement phase. The sequencing of construction is initially planned to reflect the most logical and cost effective approach to meet startup dates. As engineering and procurement schedules are further developed total compliance with this philosophy may not be possible and compromises are required.

1.9.5 Start Up

The final phase of the project is facility start up, in which the facility serves the purpose for which it was built. The demobilization of the construction contractor also takes in this phase. This phase represents the ending of all the previous phase activities.

The typical construction facility is an assembly of multiple independent units. Start up activity does not commence until all of the components that make up one

of these units are complete. Consequently, construction activity relating to a unit must be completed concurrently so that coordination will exist with the requirements of the startup schedule. Turnover to the owner occurs when an independent unit is ready to be accepted by the owner. It can be accomplished unit by unit, or for the project as a whole.

1.10 Summary

In this chapter the process of construction, its constituents and the interaction and generic structural set between the various players is described. This lays the ground work for the discussion in the following chapters.

Chapter 2

Background Information

This chapter presents a literature review as background information for further discourse. The information includes what is the present view of researchers about scope management: its causes and some of the remedies. In the discussion are included the views of the author of this thesis and how they concur or differ from the published work.

2.1 Literature Review

By going through the literature on scope management the first observation was that there has not been much research done on the subject. Therefore it is a fairly open topic and a lot needs to be done. In fact this is probably the first work done directly on the subject because nothing in the literature deals solely, totally and comprehensively with the subject of scope management uniquely. This thesis by no means fulfills this need but atleast serves as a initial building block for further research and discourse. Most of the research done has made very little or no distinction between scope changes and other changes and cost overruns. This thesis attempts to define scope changes as a separate issue, as we see in chapter 1, so that the importance of this problem can be appreciated and attention focused on it. We shall see in chapter 3 and 4 that part of the problem is not appreciating the existence of scope management as a problem. Once the attention is directed towards the problem, the problem is identified, its

existence acknowledged, one solves nearly half of the problem. Further it was observed that most of the researchers give factors which can effect the scope definition process and then go on to describe the change control process. There is one major flaw in this approach, which is that the change control, which they describe is for changes happening in the construction phase. It has no remedy for rectifying faults in the scope definition phase. The view of the author of this thesis is that scope definition is a process which happens during the conceptual phase, and there is a process of scope modification which happens in the engineering phase and procurement phase. Both these processes should be the focal point of a scope mangement program and no scope changes allowed to happen in the later phases. The change control prescribed in the literature deals with the evaluation of changes and their implementation in the construction phase. Which includes issuing the authorization to carry out the change known as the change order, applied to any change in the construction phase. So there exists a gap between the analysis and the remedy.

A paper by Mark [12] concentrates on the decisions within the phases which according to him initiate the activities that define the constraints for each phase. He suggests that factors that influence the choice of action to be taken in the early stages of a project vary in importance to the decision maker and also in the degree of uncertainty. In other words outcome of each decision is influenced by a set of factors that vary in importance and uncertainty. According to him it is important to know both; factors which influence certain decisions and as well as the sources of these influence factors.

These so called "influence factors" are categorized by Mark into approximately 20 different areas and each influence factor is associated with a specific project organizational group, such as the owner, project management, equipment vendors, or operating plant personnel[1] as shown in Figure 2-1 taken from Mark [12].

In his paper he discusses the combined effect of these influence factors and the decisions taken by each organizational group. Some of the discussion is presented in the following sections.

[1]The article deals with scope definition of petro-chemical industry.

Client

Corporate Planning

Intracorporate Communication

Outside Vendors

Equipment Availability

Equipment Vendor Quantity

Project Management

Technology Expertise

Manpower Availability

Time Availability

Historical Information

Past Project Procedures

Company Specifications

Contract Type

Manpower Experience

Operating Plant

Operating Plant Preference

Plant Layout

Site Conditions

Enviromental Conditions

Utilities Available

Output Guarantees

Pollution Control Limits

Other

Market Conditions

Escalation Rate

Technology Development

Figure 2-1: Influence Factors [Mark [12]]

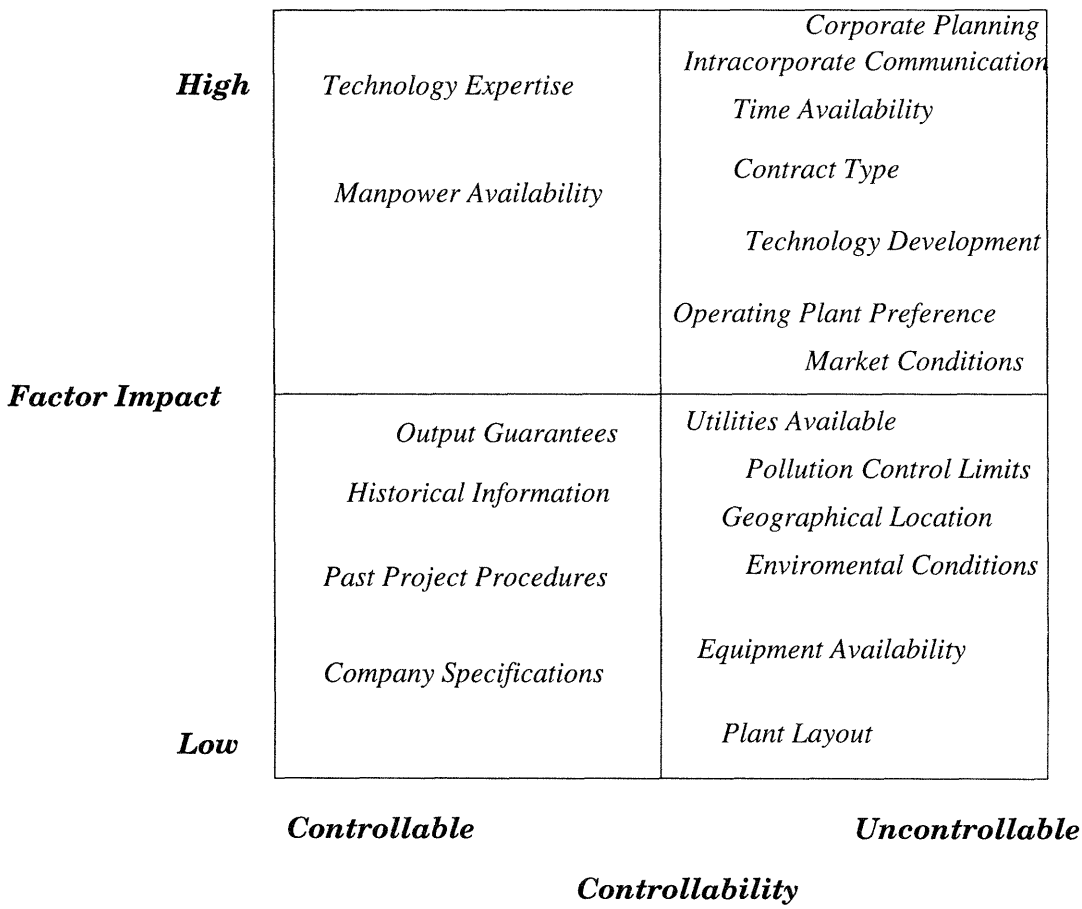

Figure 2-2: Controllability Vs Factor Impact [Mark [11]]

In an another article [11] by the same author it is suggested that when comparisons are made between potential problem areas and early decision making, factors that highly effect both problems and decisions must be controlled if possible. This is no doubt the correct approach. But his view that the influence factors which are uncontrollable will always be uncertainties that must be dealt with when making decisions is not correct. It can be argued that all factors are controllable to some extent no matter how uncertain they are, or at least can be prepared for, if a proper methods of analysis, process, and control are used. The classification of these factors according to Mark [11] is shown in Figure 2-2 taken from Mark [11]. For example the technological change can be forecasted nowadays with fair accuracy if a proper systematic survey is conducted with proper personnel and tools.

Comparisons among the early project decisions and subsequent problem areas, highly affected by the same influence factors are useful to the decision maker in determining what action to initiate to lessen the detrimental impact. It is also important for the decision maker to know where each influence factor originates so as to focus his attention on the factors that are controllable by himself.

2.1.1 Role Of Client/Owner

In his article Mark [12] identifies the factors related to the owner group into the two areas of corporate planning and intra-corporate communication. He considers the decisions influenced by these factors as the most important decisions pertaining to the project, and are related to the problem areas with the greatest detrimental impact on the completion of the project. This is fine and agreeable but it lacks the detail and the distinction between the factors that effect the scope definition process and the modification process. The model also fails in addressing the iterative process with which these decisions are taken and the cumulative effect of these iterations, but on the other hand very rightly rates the influence of corporate planning as highly important to numerous decisions within the early phases of a project, and significantly related to the major project problems of undefined scope parameters, undefined organizational authority, and underestimated project costs.

In another article Mark [11] concludes that owners of planned facilities are a major cause for changes to the scope throughout the project's entire life cycle and most owners will continually perform feasibility studies to ensure that the project will yield the expected financial benefits. If the market need changes, technical changes to the project will be necessary. In his view this is especially true on cost reimbursable contracts, where owners will make changes for operating, maintenance, and marketing requirements without realizing the impact on construction costs.

Another author in his article [James [8]] describing the owners role in scope definition gives following reasons as to why owners are willing to proceed on the basis of inadequate project definition.

- Owner does not have engineering expertise to provide complete conceptual definition.
- If the initial order of magnitude (feasibility) estimate looks very favorable, there is no reason to spend additional funds in scope definition.
- As a matter of economy, owners want to limit the amount spent on feasibility and project authorization/budget studies.
- The shorter the time spent on preliminaries, the quicker the job can be completed and the lower the overhead.
- High interest rates make the project duration critical.
- Market pressures make the project duration critical.

And he concludes that owners consider market pressure to be the single most important reason for under developed scope. The reasons for this single factor he lists as follows

- Demand for a product, while intense may be short lived.
- Many marketing analysts have noted a trend toward short product life cycles, particularly in technology intensive industry.

- Competition in product development has increased.

This view is also supported by Charles [15] " Most projects are market-driven, if a project is delayed by ponderous research, the market opportunities may be lost . In addition he contends that 90% of early-stage projects never materialize, only the other 10% are the ones that continue into the detailed estimating for the later stages of engineering, procurement and construction.

In many cases, profits to be derived from plant operation seem to greatly out weigh changes in construction costs. An example cited is the Alaska pipeline where poor scope definition plus regulatory and environmental problems caused the project cost to rise from an estimated $900million to more than $7 billion. In spite of this the project is considered a success and profits have overshadowed all cost overruns.

In support of the market pressure argument, most industry representatives contented that further scope definition of scope would add to project duration up to 25%.

Some other possible reasons for inadequate scope definition suggested by James [8] are

- lack of, or less than full use of engineering capability within the owner organization to conceptually define a project.

- The euphoria that can accompany early cost estimates and revenue projections that are extremely favorable. In their haste to realize these revenues as quickly as possible, owners compromise good planning and scope definition.

2.1.2 Designers

In the literature researchers have not treated the designers and the constructors as separate entities but rather have grouped them together under the heading project management. In my view this is not a correct approach. Both designers [see section 1.7.1] and constructors have separate interactions and influences on the scope

development process[2] and hence deserve a separate analysis.

According to Mark [12] past experiences such as past historical information, project procedures, contract type, and manpower experience of the project management in under-taking similar types of projects are critical to the scope definition process such experience is needed for proper definition of project control systems, prior to the undertaking of any major construction project. In this thesis a similar suggestion for the designer firms is made because interface of the owner and designers is much more important than the interface between the constructors and owner, especially in the scope definition and design process. The owner and project management interface becomes more important in the later stages of engineering phase and onwards.

The basic thought of thesis is that the all the decisions pertaining to scope changes have to pass through the owner regardless of any arrangement with the other players. The issue of scope change usually involves financial strain. Therefore these decisions invariably have to be taken by the owner himself usually with direct meetings and involvement. The construction manger is only a advisory tool in such cases and as will be discussed later on, he can only influence knowledge of the owner, and that too depending on the his structural arrangement with owner.

Design changes are another major cause for modifications to a project scope. Since multiple design disciplines are working, sometimes independent of each other, toward a fully integrated design, there is bound to be areas of confusion. These professionals must continually balance process design and structural engineering considerations with regulatory, maintainability, servicability, and human factors considerations, and being human will occasionally overlook something. In this atmosphere, there is considerable potential for design interferences, congested designs, and interface problems, all of which often lead to changes.

[2]In this thesis the term scope development used to the denote the whole process of scope definition and scope modifications

Constructibility and Safety

Changes due constructibility problems and changes due to safety considerations can also result in scope changes . According to Mark [11], these changes are more frequent on industrial and power projects than other types of construction. But nevertheless scope changes due to constructibility and safety can also happen in other type of construction projects, because designs that have taken into account issues that affect how a project can be constructed more efficiently are reducing construction costs on every type of projects.

Ideally constructibility is taken into consideration during conceptual engineering phase so that this knowledge can be reflected in the first designs. Still, the need for some constructibility changes may not be evident until later and these must be formally evaluated as potential scope changes. Unfortunately, these constructibility issues are usually not addressed until the design efforts are well under way. As with design changes, constructibility changes also cause numerous impacts on design plans as well as discontent among design professionals. Value engineering also has a similar effect.

2.1.3 Procurement

According to Vickroy [8] the practices of delayed bulk material tracking and ineffective change control contribute to the scope control process, and much of the variability problem is associated with off-sites (access, utilities, and other area-sensitive costs). He states that these are more a function of geographic location, plot plan and arrangement than of equipment and quotes (Merrow, 1981) , " Most of the variation found in cost estimation error can be explained by the degree of definition of the project's site and related characteristics".

In his view the installation of bulk quantities accounts for about 75% of field labor costs on an industrial project so such quantities have a significant cost impact. Until all drawings from a project are completed and bulk quantities taken off, material and labor costs associated with bulk quantities remain uncertain.

In addition he thinks that since construction progress is often measured by ratio of bulks installed to total bulks, poor bulk definition inhibits accurate progress measurements, and the effects of bulk quantity overruns surface late in the project that is in the construction phase yet the decisions that determine bulk quantities are made in the engineering phase.

In the view of the author of this thesis this is problem of cost overruns rather than scope changes. The only way bulk quantities can change the scope is their unavailability or faulty specification in terms of quantity and quality, the revision of which could cause a scope changes as described in section 1.3 and 1.4.

2.1.4 Operating And Maintenance Staff

Another source of changes is the operating and maintenance staff [Vickroy [8]]. These are the people that must live with the complete facility and they should have a voice in its design. The literature suggests the following guide lines

First they must be brought on board early in the conceptual design process. The later their ideas are introduced, the more costly will be any changes. It is particularly dangerous to wait for their input until the construction phase. Second their ideas should not be accepted without proper analysis. Is the change just for someone's convince or because that is the way it was done in the past? Is the idea cost effective, is there an equally effective way that is more cost effective? Will these personnel actually the ones assigned to the facility? If not, one can expect those actually assigned to have ideas of their own.

The suggestion of the author of this thesis is that in addition to the above guide lines, we can bring the users in the conceptual phase in such a manner that they are become a part of the project from the start. The way we benefit more by their input is that we improve their knowledge and insight to the construction process so that their input improves in each cycle.

Chapter 3

Scope Development

The process of scope development can be said to be comprised of two main sub-processes, scope definition and scope modification process as shown in the Figure 3-1 on page 41. The overall scope and the scope of the subsequent units and subunits is set out in the conceptual phase in the order which can be a predetermined, norm or developed as the process goes on. It is possible as hinted in chapter 1 section 1.9.1 that some other activities may also be carried out in this phase depending upon the project and the policy of the initiating players that is the owner, sponsor, or some owner representatives. Scope modifications are usually carried out in the engineering phase, the reason being that as the engineering progresses the faults in scope definition are discovered and enough time has lapsed for other influences to take effect as shall be discussed later in the chapter. The overlap of scope definition process and the scope modification process is due to the fast-track nature of the project and the extent of overlap is the same as the overlap between the conceptual and engineering phases.

3.1 Scope Definition

Scope definition is the detail with which a project is defined that is starting from the overall functionality of project to the last definable functional element in descending order similar to the break down of structural or estimating hierarchies. As we see in the Figure 1-1 on page 10 in section 1.2 an extent of definition upwards and inwards

can be termed as rough or weak and outward and down ward as better or detailed. If all units are defined than horizontal scope definition is completely defined. If the lowest tier of subunits are completely defined than vertical scope definition is completely defined. The example of horizontal scope change would be addition or deletion of a major unit and the example of vertical scope change would be a change in the functionality of a existing unit. The process of scope definition takes place in the conceptual phase.

Usually individual units are much more bigger than a subunit of another unit, excluding the exceptional cases where a subunit is a huge piece of equipment or the heart of the project. So it is clear that generally the horizontal rough definition has a larger effect on the project scope than the vertical rough definition.

As the number of units is always less than the number of subunits and so on. It can be safely concluded that the the frequency of vertical scope changes are more than the frequency of horizontal scope changes.

There can be two basic flaws in scope definition one is incomplete scope definition and the other is faulty scope definition.

3.1.1 Incomplete Scope Definition

Incomplete scope definition means that at any level of definition, horizontal or vertical, some definable element is missing. This element can in some cases be whole unit or subunit. Incomplete scope definition can be intentional or unintentional. According to the literature surveyed by the author of this thesis these omissions are intentional compared to the faulty scope definition. The primary reason suggested by the literature as discussed in chapter 2 is the market pressure or the duration constraint. In most of the cases the suggested reasons conclude a opportunitistic approach on the part of the owner. In the view of the author of this thesis there can be a lot of unintentional reasons such as lack of knowledge, experience, attention or imagination which can cause incomplete scope definition as shall be discussed in section 3.4

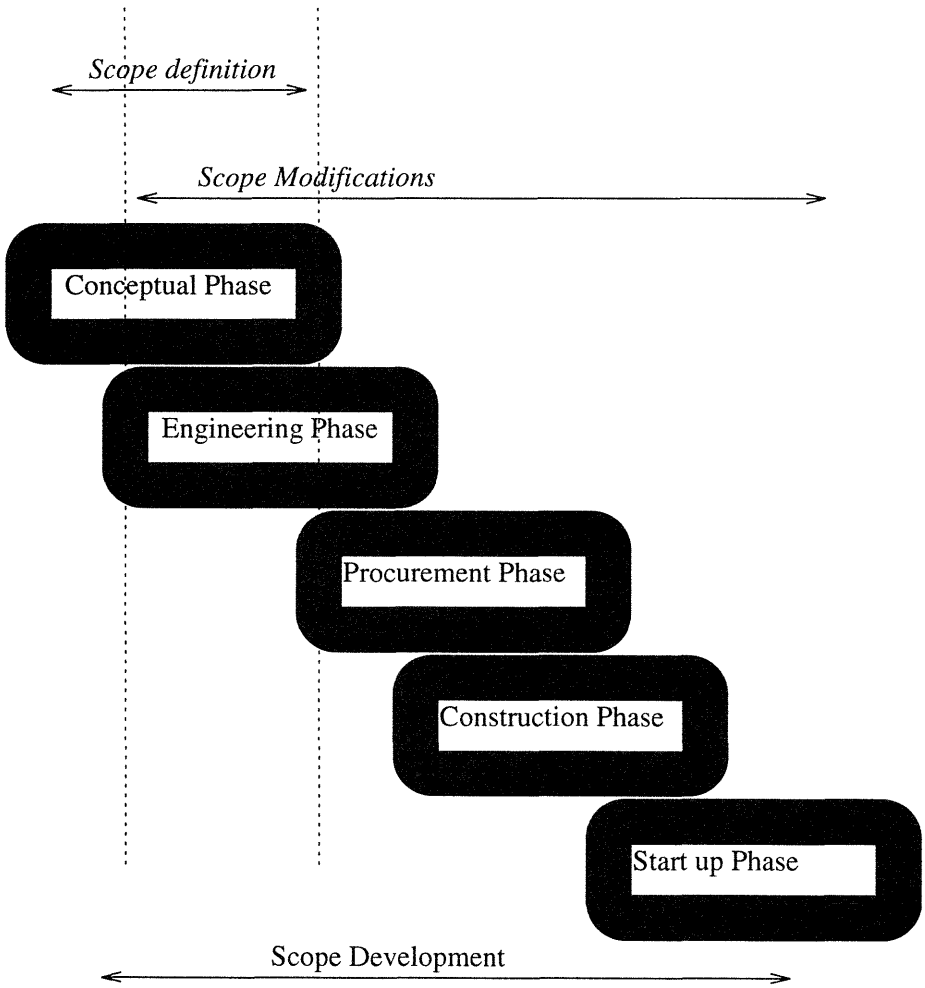

Figure 3-1: Scope Development Process

3.1.2 Faulty scope definition

Faulty scope definition means that at any level of definition both horizontal or vertical some definable element has been wrongly defined. Compared to incomplete scope definition the faulty scope definition is usually unintentional. One of the characteristics of faulty scope definition is that the some parts of the project are so specified or designed which the industry environment can not provide the example of this would be highly customized fabrication for which the material, supplier, fabricators or the designers are not available.

The other two characteristics of faulty scope definition are as described in chapter 1 that is the wrong specification of size or type of an activity. Scope change happens when these faults are discovered and need correction to such a extent that the border line is crossed as shown in Figure 1-2 on page 12 in section 1.3 and Figure 1-3 on page 14 in section 1.4.

3.2 Scope Modifications

Any change in the scope definition is known as a scope modification. This modification may be of any kind as listed in chapter 1 section 1.2.1 on page 11. Scope modifications usually start happening during the engineering phase of the project. In unusual circumstances they can also happen in the subsequent phases. These are termed as late modifications. In this thesis any scope modification which happens after the engineering phase is termed as the late modification. The most important factors that lead to scope modifications are the incomplete scope definition and faulty scope definition.

Other causes are due to fault in the design activities which are underway in the design phase. Which as discussed in chapter 1 can be in the size or type of an activity.

3.3 Factors Influencing Scope

Following is the definition of some of the influences which in the view of the author of this thesis effect the scope development process. First the influences are described then later on their effect on the scope definition phase and the scope modification stage will be discussed.

3.3.1 Sponsor Influence

The following two influences can be imagined to be acting from the sponsor in the the context of scope changes.

Funding or Finances

First and foremost influence is of the capital that has to be made available for the project to be constructed. It is the amount of money that the sponsor has or can afford on a current project. This amount of money in some cases determines the final functionality or in some cases the fate of the project as discussed in section 3.4 on page 50.

If after a scope change the cost increases too much the sponsor can have second thoughts as to proceed with funding of the project. The thought of losing or making money can change the thoughts of the sponsor, which can influence him to change the commitment to the owner. The sponsor might ask for a supplementary feasibilities and reconsider the project, the amount and terms of financial commitment.

It is quite possible that the owner and the sponsor be the same entity or the case may be other-wise. Whoever controls the flow and sanction of funds influences or has the final word on the consideration of the scope change. In most cases it is the owner who acquires the money for the project on his personal or organizational responsibility which ever the case might be and therefore has the final say in the decision making process.

Other Prospects

This signifies the relative importance of the project compared to other deals that are available to the sponsor. The sponsor can be influenced by the other market deals which he comes across. If in his view he can maximize profits else where he might tend to withdraw, even if not completely he still can cause a lot problems for the owner for whom the project might be very important.

This might be especially important in case of a cost increase if the scope changes due to reasons other than the sponsor influence. It might cause the sponsor to back away from the project and thereby creating problems for the owner and the project, as any new sponsor and the period lapsing in between can result in further scope changes. The reasons for this might be the change in the idea, risk or the feasibility of the project to the owner during the the period he searching for the new sponsor. Further more the new sponsor might have his own influence in terms of his desires, ideas and profitability. In the section 3.4 it shall be discussed that during any such lapsing period of no activity, due to the change in experience and the knowledge of the individuals there desires can change. One of the recommendations of this thesis is that this period can be usefully utilized by improving the knowledge of the individual and also rightly directing or orienting it.

3.3.2 Owner Influence

The factors affecting owner are

Experience

In the context of construction experience is defined as the amount of exposure to or involvement in construction activity an individual has had. The type of experience in terms of type of projects is also important but is of secondary importance compared to experience with some/any sort of construction activity. For an individual who has been in construction business for sometime this type of experience is directly proportional to his age as shown in the Figure 3-2 on page 45.

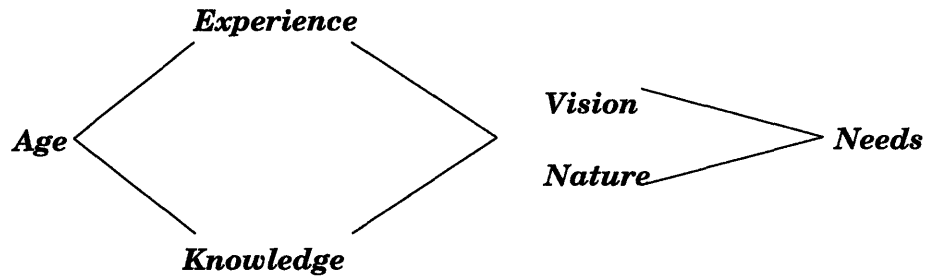

Figure 3-2: Need Factor

Knowledge

In the context it is meant the knowledge of technical know how of construction. Most of the faults in the conceptual phase and the engineering phase take place and go on unnoticed due to lack of knowledge and experience of the direct players.

A proper mix of experience and knowledge is necessary for participating as a player in the construction process. The absence of any one them is theoretically not possible without the other. The reason is that during the process of attaining knowledge of construction one gains experience, because the true knowledge of construction cannot be attained without practical experience. Also while acquiring experience one automatically becomes somewhat knowledgeable of construction. But the experience and knowledge attained this way might not be in the proper mix.

Vision

It is the perception, imagination or foresight of an individual and is a characteristic which varies from individual to individual. In construction it is the ability to foresee, understand the out come of a plan or a venture. It is usually understood to be something in born and intuitive but as shown in the Figure 3-2 it is dependent on the knowledge and experience of the individual and hence can also be described as learned behavior. Therefore it essentially improves with age and can be improved to a marked extent by the improvement of an individuals knowledge and experience. The reason for this improvement might be that as the individual moves down the learning curve and gains more maturity in terms of construction his imagination improves.

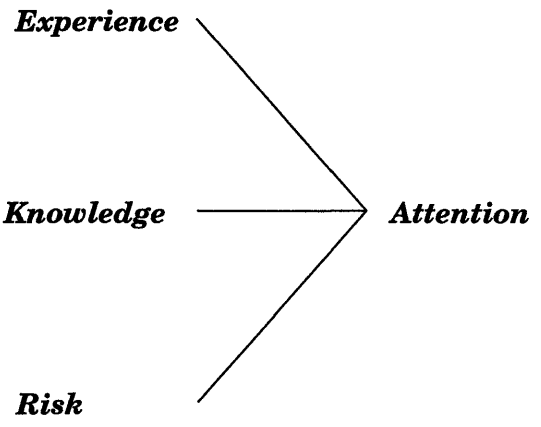

Figure 3-3: Attention Factor

Risk

By risk it is meant the risk propensity or the risk adversity of an individual. Risk is a intersinic part of the nature of an individual. As shown in Figure 3-3 on page 46 it plays a major part in the attention factor but has little role in directing needs of an individual. Being a risk taker or risk adverse has no effect on an individuals desire. One may long for something but might not go head with it if it is risky and vice versa. It is clear that if a person has a propensity for risk he is more likely to go ahead with a project with a incomplete scope definition. This behavior can also be influenced by the change in the experience and the knowledge of the individual as discussed in chapter 4.

Nature

Nature is the attitude of an individual to the environment. It includes tastes, likes, dislikes, risk adversity, risk propensity, socializing behavior, and the negotiation skills of an individual. The general view is that, it is in-born but there are areas of nature which can be improved by improving an individuals knowledge and experience. Based on this premise the nature is shown to be dependent on knowledge and experience in the Figure 3-2 on page 45.

Needs

Needs are defined as the desires of an individual. They are a function of vision and nature of the individual as shown in the figure 3-2 on page 45.

Attention

Attention can be described as the the extent of consciousness an individual has of a situation. In the view of the author of this thesis this one of the most important aspects of scope management. The reason is that if a person is not conscious of scope changes and their impacts then he might tend to be careless in the process of scope definition, and consequently the chances are that he would proceed with a relatively in-complete scope definition. So by making people appreciative of the problem that is to direct their attention towards the problem can produce good results. As we see that a person who has some experience of construction will be quite conscious of the fact that scope changes can happen, so therefore he would be more attentive to the problem. Lack of knowledge of construction also leads to this lack of attention so we see that attention is dependent on the experience and knowledge of construction.

3.3.3 Designer Influence

Apart from the above factors which are common to both the owners and designers the unique factors affecting designers are

Technology

Aside from the incomplete scope definition and the mistakes in the definition process technological change is a very important factor in the scope development process. Technology changes very fast and to keep up with it and to make use of the latest technology changes in design become necessary. Although change in technology can be in any area but one very unnoticed might be innovations in smart tools of construction, a new hoisting or crane technology or even just simple innovative construction techniques. It has been noted that if more time is allowed for deliberations the people

want to have the latest technology and by their procrastinating attitude and waiting for the new technology can cause scope changes. Because it might be that the new technology may require different size and types of dependent items and the change in the size and type might cross the border limit and thus result in scope changes, not forgetting that the new item of technology might itself be a scope change.

One of the most common ways it can cause scope change is, if for example it is piece of equipment or machinery it can cause a scope change in two ways. It might give an added functionality to the system or even if does not do so it might cause a size or a type change in the adjacent or the dependent activities.

Constructibility

In very simple words constructibility is defined as making sure that the synthesis of all the design pieces occurs as planned without any hitch. The reason it causes a problem is very simple. If a portion of design is such that it can not be constructed then it can cause a scope problem. The earlier problems of this sort can be discovered and addressed the better it is, because in the late stage of modification the impacts will be more.

Safety

It may happen that a project is very well designed and is perfectly constructible but might not be safe or conform to the safety standards. The designs are checked for safety the same way as for constructibility and in some events might result in scope changes. The very good example would be of boilers storage tanks, or even the structural support for a facade.

Historical Information

By historical information it is meant the related design information, available from past projects, which might be similar or relevant to the current project. The manner in which it causes scope changes is the wrong information or the wrong conclusion or application of the information. The extreme case might be the unavailability of

such information especially if it is a unique project, or not making use of the existing information.

Site Issues

The site issues determine the design which can provide for the required functionality of the project. Change of site or the change in the characteristics of site can cause a change in scope. The characteristics of a site include its size, geography, and geology. One of the most common ways it can cause a change in scope is litigation which might be a function of other indirect and external influences.

3.3.4 Constructor And Vendor Influence

The factor enamating from the vendors and the Constructor are similar. Which is the lust of more work if it is profitable or even some times at a slight apparent loss to keep their work force busy, if the situation requires.

This usually happens if the contract has item rates and the rates of one of the items is very attractive. The constructor tries to pressure the owner through various ways to get an increase in that item so to better his margin. A lot of underhand transfer of favors can occur and in some cases causing scope changes if not controlled properly. A hypothetical example would the design of slurry walls in the central artery project. If the case is presented properly and promoted by the concerned properly a provision can be made in the design of slurry walls to support multistoreyed structure on top. Now such a structure might not eventually get ever built but it can be a cause of scope change at present.

Similarly recession can be cause of scope change because if the contractor fails to earn by claims and extend the project scope he might as well run out of business, actually in such cases the government also supports such strategies to keep the economy running or to appease their favorites.

3.3.5 The Influence from Indirect Players

Influences from the indirect players are as follows

Public

The public constitutes the locals who are directly affected by the project in some way and the indirect affecties who do not live in the vicinity of project but are affected in some way by the project. This indirect effect can be economical, environmental or simply might be a disturbance or intrusion into some sanctity. The public might be public at large or be in form of some organized group. The public can lobby for or against and change the regulatory opinion, or by propaganda the rest of the public opinion about the project.

Regulatory

There are numerous regulating agencies who have their specific control procedures and yardsticks for various scenarios and regulate the projects through formal permits and orders. They can become a cause of scope change if the original design does not conform to such regulations.

3.4 Factors And Scope Definition Process

As already stated the first phase of any project is the conceptual phase and as shown the scope definition takes place in this phase. As the words conceptual and definition indicate this is the time when the concept of the project is evolved and the scope of the project defined or stated. First of all the overall scope of the project is defined and then the subsequent units and subunits and their details. In the start as already pointed out in section 3.3.1 the overall scope is based on the needed functionality, but in the end it is function of how much money is available for the project. If the project is of a very important nature than the functionality comes first and then the finances. The funds are made available if the project is feasible enough and important. A good example of this scenario this the Super collider project in

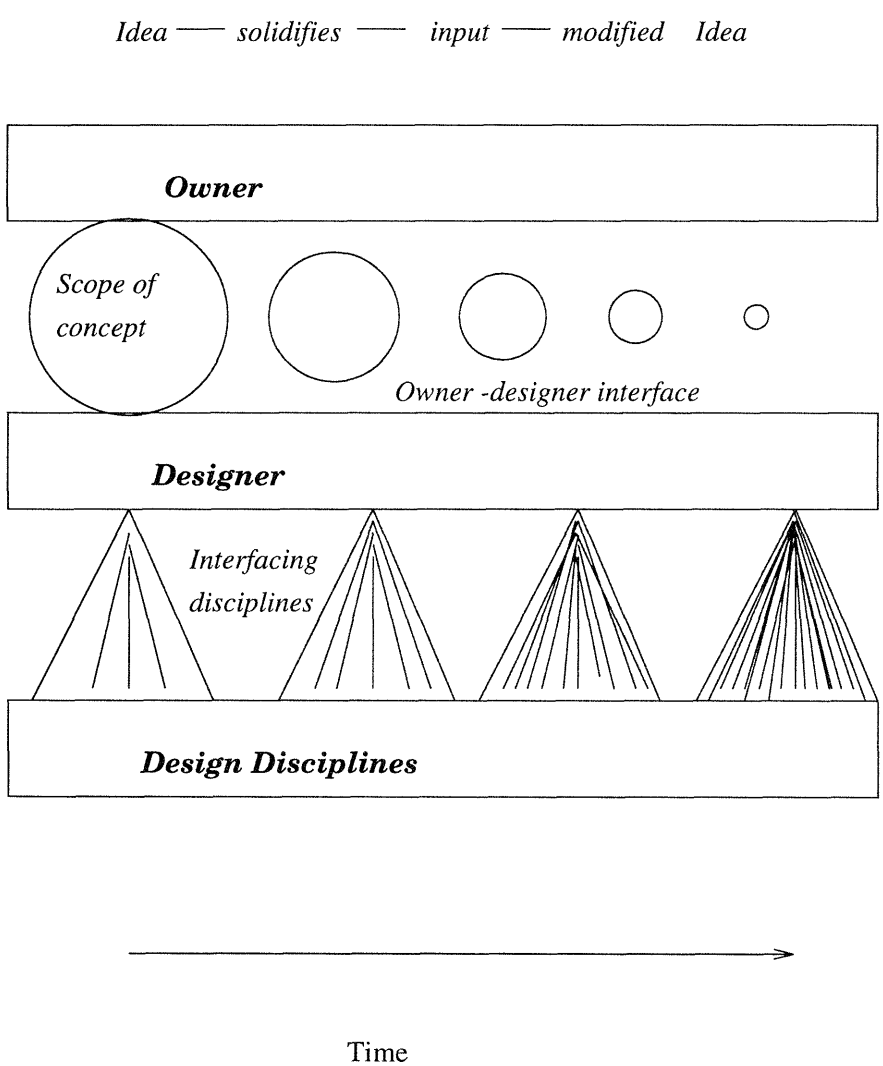

Figure 3-4: Definition And Modification Cycle

texas which had to be scraped because the required functionality fell short of the feasibility of the project and the sponsor backed out because it was thought pointless to go ahead with a project delivering lesser functionality.

The Figure 3-4 on page 51 shows the the idea development process or in the case of modifications modification development process. The circles show how a broad abstractness is narrowed down or defined as the process goes on and triangles show the increasing number of design disciplines as the project moves on. At the start of the conceptual phase the owner conceives the idea which is usually the result of or is based on his needs and desires. At this point in time the owner has only an abstract idea which he conveys usually verbally to the designer which is an architect.

This idea acts as the initial input to the process of idea development. This input is then processed by the preliminary designer which in all cases is an professional architect. At this stage for the first time an abstract idea is transformed in something solid to which the players can relate to than on.

During this process that is the first iteration the idea gets some input from the designer and may not be as original as thought by the owner. Also during the original presentation of the idea the owner himself does not know the completeness of the output he desires.

When the solidified idea is seen by the owner after the first iteration, new ideas come to his mind partly because some of the abstractness has been transformed in to reality this usually happens because of the lack of owners knowledge of construction and his lack of experience. At this stage the owner also might feel that his idea has not been followed properly which might be due to the fact that the designer has already modified or redefined some of his unrealistic ideas. This kind of a conflict is obviously due to the large differential between the owners knowledge and experience to that of the designers knowledge and experience. Here it should be kept in mind such differentials exist between all these players due to their knowledge, experience, position in the environment and their respective varying interests.

During the time lapse between the iterations the knowledge and the experience of a person can change, due to the results of the previous iterations or some other

external inputs. which can cause a change in his vision, nature and thereby changing or effecting his desires and attention. This change can be positive one or a negative one. We can captilize on this and cause it to change for the better by effecting the knowledge and the experience as discussed in chapter 4.

This becomes a cyclic process till some definition of scope is reached. It is important to note that at this stage the scope might be overall or of an independent unit. The usual procedure is that first the overall scope is defined then the scope of units, in some cases a unit can be defined earlier than another dependent or independent unit if the project is fast track. In case of dependency the interfaces must be defined along with the units.

In this cyclic process we see that three main things two of which are the owner and the designer and one is the interface between them plays a major part in scope definition. Another influence which is also very important is the sponsor influence that is the financial influence.

It should be noted that all the inputs from the owner are dependent on his needs. The needs of the owner are the direct function of his experience and knowledge of construction. The role that the owner shall have in the scope definition and the consciousness that incomplete definition can cause scope changes is also dependent upon his knowledge and experience. Similarly as designers are also composed of various individuals their inputs to the definition process are also influenced by the same kind of factors. This idea is depicted in the figure 3-2 on page 45 and the figure 3-3 on page 46.

In the authors view starting point of the influences is the age of the individual which determines the kind of knowledge or experience he has gained. Which in turn forms the basis for his nature and vision as shown in the Figure 3-2 on page 45. This vision and and nature in large part determine the needs and desires of an individual, this is applicable to any individual including designers.

The knowledge, vision, and nature especially the the risk propensity or the risk adversity part of the nature determine what kind of attention the owner will have to the problem. Here it may be noticed that all this is being presented in context of

scope change. So we see that the two important influences are attention and needs from the owner. In case of multiple owners the all these factors have a balancing effect or cumulative negative effect depending upon the knowledge and experience of the different individuals and the weightage or influence of their decisions on the project.

One major point to note is that ultimately all these influences have to pass through the owner for approval because he is the final deciding authority on the matter. This assumption stems from the fact that the individual who owns the project and arranges for the finances has the final say in the decision .

Each of the scope definition cycle involves the influence of the the basic factors. The basic factors of scope definition involve all the factors of the owner and the attention of the designer and the funding of the sponsor. So we see the that knowledge and experience of construction plays a important role in each cycle. This activity happens in a, or successive interviews with the designer. In this process the owner to make his abstractness clear and the architect to understand usually refer to already built examples in real life or in design literature. This activity is so hectic and time consuming and probably unreliable or un-satisfying that mostly the designs built else where are copied to save cost and ensure acceptability of whatever is going to be built[1]

During this process other influences that is indirect influences from the regulating agencies and the public might also alter the definition, but at this stage it serves as a blessing in disguise, because if definition conforms to the regulating requirements at this stage it can save the scope modifications later on. The major reason that these indirect influences cause changes in scope is due to the lack communication between the owner or its representatives with the public and governmental agencies. The earlier these agencies are apprised of the scope of the project the less shall be the problems of scope changes due to them.

This process of scope definition as already mentioned in section 3.1 on page 39

[1]This might as well be the prime reason for the copying of designs, but the problem still remains with one of a kind projects customized designs and items.

can result in two major flaws namely incomplete scope definition and faulty scope definition.

During the idea development due lack of the attention factor and misunderstanding between the owner and designers it quite possible that a unit or a subunit escapes definition, and it is also quite possible that size or type of a unit or a subunit be wrongly specified.

Another major mistake that can occur during this process is that the some parts of a project be so defined which the industry environment can not provide.

3.5 Factors In Modification Process

As the parts of the project move from the conceptual stage to the engineering phase these parts move from the scope definition stage into the scope modification stage. This might be not very clear from the scope development diagram 3-1 on page 41. The way to interpret the diagram is that at the point when there is no overlap, the overall scope of the project has been defined and some of the iterations of the idea development are complete and a reasonable scope of the project exists. In the overlap zone as a portion gets out of conceptual phase it gets in to the engineering phase by the property of the fast track process and hence the scope definition stage is followed by scope modification of that portion. Hence the results of the scope definition stage become the inputs of the scope modification stage.

The individual influence factors for the scope modifications are the same as the scope definition stage but now as the project is in design stage the emphasis or the influence of the players change for example in the definition process the influence of the owner is more or important, similarly in modifications stage and in the design stage the influence of the designer becomes more important, and as the modifications continue well into other phases the role of vendors, contractors and other indirect influences as described in section 3.3.5 indirect players gain importance.

As engineering progresses the mistakes of incomplete scope definition and faulty scope definition are identified and the need arises for scope modifications. The mod-

ification process is also a cyclic and iterative process just like the idea development process except in this case instead of ideas, scope is being modified therefore the influence of designers has a greater effect. In this case the incompletions and faults are identified by the concerned designer discipline and conveyed up the hierarchy to the lead design engineer or the construction manager as the case may be, and becomes a initial input to the scope modification process, when put in front of the owner for decision and approval.

The other causes of scope modifications arise from the within the engineering phase itself. These are due to mistakes in the design. These mistakes occur due to the lack of knowledge and the experience of the designers. The chances of such mistakes are greatly increased due to the large number of designers working for different disciplines as shown in Figure 1-5 on page 18.

The lack of inter-communication between these designers and disciplines is also a cause of most of the problems. As the modification process goes on more design disciplines become involved, and as shown in the Figure 3-4 the number of interfaces increase. There might also be problems due to lack of direct communication between the designers and the fabricators and the constructors as shown in Figure 1-7 on page 21.

During the engineering phase the process of scope modifications might also be influenced by the external influences of the public or regulatory bodies, and in very rare cases by the influence of constructors or vendors.

3.5.1 Late Modifications

These are the modifications which happen very late in the project that is after the engineering phase of the project. These are usually the result of faulty engineering in the engineering phase and influences from direct and indirect players.

Part of late modifications are due to faulty specification and design in the engineering phase and part from the external influences, but some modifications can also be due to the incomplete definition and faulty definition which has gone somehow unnoticed upto this stage.

The fault due to faulty engineering can be in size and type of an activity, wrong specification or non specification of details. The reason for these faults is the lack experience of designers, knowledge, and the information available to them.

The influence of external factors is more important in this phase. There can be public out cry over some environmental issues or legal rights issue. It is also possible some regulatory law changes during this time and court orders the implementation, or the public wins a litigative issue.

3.6 Scope Influence Diagram

In the light of the above discussion the scope influence diagram can be constructed to as shown in the Figure 3-5 on page 58. The diagram depicts the action of influence in one glance at any instant in the scope development cycle. The influences of the various players are shown. The most important aspect of scope development that this diagram points to is the fact that all the decision concerning scope changes have to be ultimately approved by the owner and after the approval whatever the scope change might be it causes a change in the estimate of the project. This change in cost whether an increase or a decrease can further cause a effect on the attitude of the sponsor and a change in the flexibility of choice of the owner.

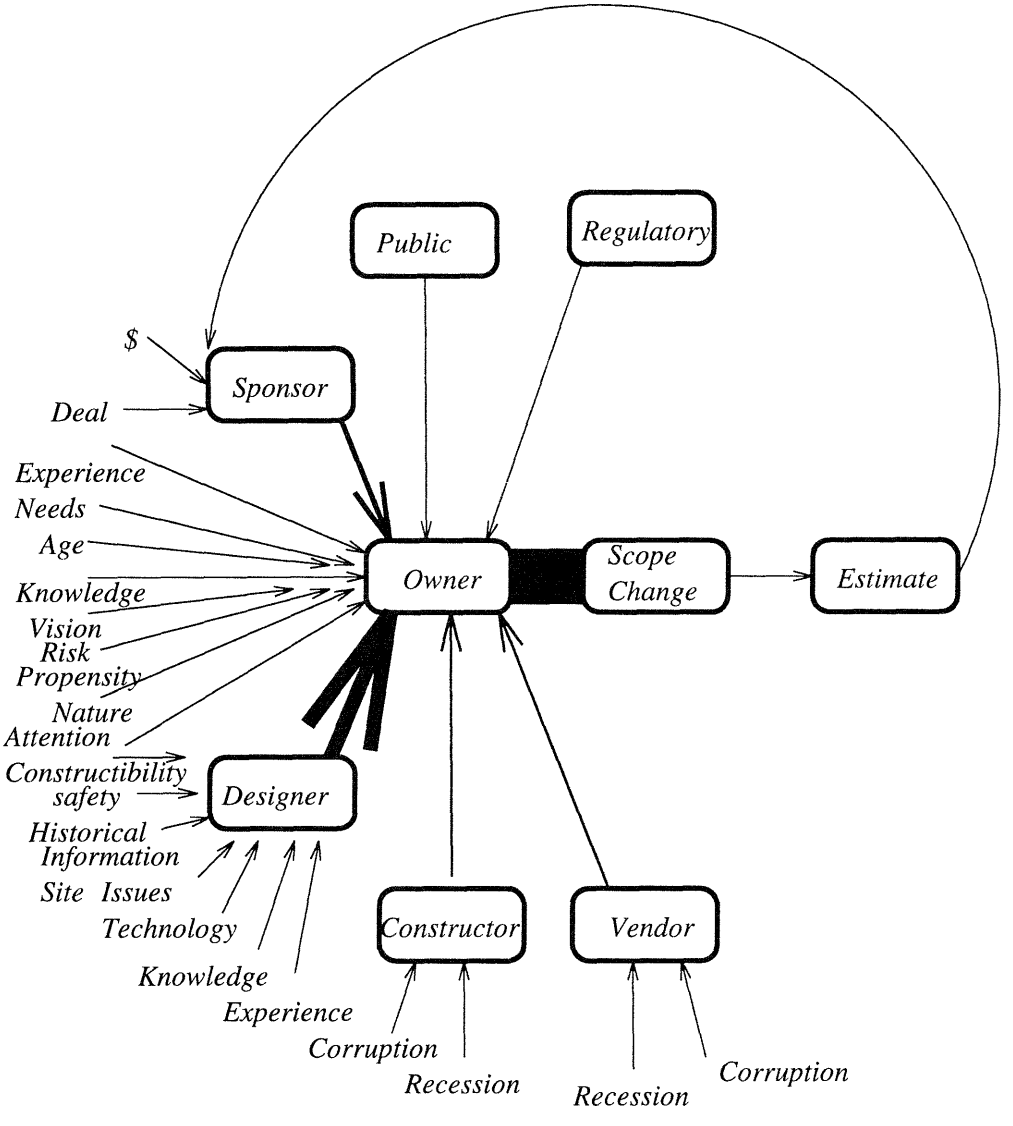

Figure 3-5: Scope Influence Diagram

Chapter 4

Scope Management

In this chapter some recommendations and procedures are presented for scope management.

Looking at the scope development processes in Figure 3-1 on page 41 it is clear that both the definition and the the modification process are to be managed. In this chapter we shall look at the step by step management of the scope development process. In the first section the recommendations for the scope definition stage are presented and in the later section recommendations for the scope modification stage are presented.

4.1 Recommendations For The Definition Phase

In this section we shall present some procedures to better the scope definition process. That include

- Basic Research

  For better definition, analysis and selection of needs, of the owner.

- Preparation of a scope statement

  Which forms the basis for initial scope document and helps focus the attention on the problem of scope management.

- Preparation of a initial scope document

  Which provides guidelines, forms an out line for a better definition of scope and helps to detect mistakes early on and helps prepare a good technical scope document.

- Technical Scope Document

  Which forms the basis for the detailed designs and engineering of the project.

Following are the stepwise recommendations for management of definition stage.

4.1.1 Formation Of Scope Development Team

In the first instant before undertaking any major project the owner needs to form scope development team. This team might be formed in-house or by hiring consultants as the situation might permit. The basic function of this team is to do some preliminary research and gather information for the project to be under taken. If the owner is relatively inexperienced and unkowledgeable it is good idea that this team be delegated full powers to work on the behalf of the owner. In the other case if the owner has some experience and knowledge than this team can act as a consultant to the owner.

The team thus formed should first do the necessary research and prepare the scope documents as mentioned above. For research it needs to do the following four steps which shall help in preparing the scope statement.

Need Definition

The first step is to define the needs for which the project is to be built. Based on these needs the functional requirements of the project should be determined. In this step the input of the owner and the end users is very important. Need definition is the foundation stone of the project. If this is done right the chances of scope changes slim down to a great extent.

Options Search

The second step is to gather all the ideas that can fulfill these needs, and deliver the required functionality. This is where survey of historical records, current academic research, experimental research being done can help to take full benefit of the existing knowledge of construction and related activities.

Analysis Of Options

After all the ideas are presented. They should be compared with the needs and decision taken as to which of the ideas is better suited for the needs. In this step use of computer graphics and simulation techniques can help to better analyze the options. The risk simulation programs and cost modeling programs can also help in the feasibility analysis of the options.

Collecting Information

The fourth step is to see how the selected option will be carried out what are its requirements. If an option is not selected till this stage then this step helps compare the options. This step includes method study and industry environment scan. The historical data bases combined with geographical information systems, the equipment capability and labor use data can be used to generate time sequenced simulations to get a better insight to the requirements of the options.

All this information can be logged and used for further improving the existing data bases. Because even the options which are not selected may prove useful source of information for future and hence the effort is not wasted. Infact this information can be sold to other interested parties and a profit made even if the project does not move any forward.

4.1.2 Scope Statement

After the above mentioned four steps are completed by the development team than they should prepare scope statement based on the information gathered. The scope statement should include broad description of what is to be covered in the works. The format and its presentation should be such that it should be a clear communication between the various players of the extent and nature of the project. The sponsor should also go over it and approve it. The following should be included in the scope statement.

- Statement Of Work.

  Statement of work is a brief description of overall scope. It may be brief but should be complete as possible. Ideally it should also be unambiguous and clear. It should specify the type of facility its units and subunits and the intended functionality they are expected to deliver.

- Organization Of Work

  Organization of work is an out line of how the the items specified in the statement of work are to be carried out. It may not be that detailed but at least should make some logical sense and should answer the questions of what, when, where, and how. It should also state whether the project is to conventionally built or fast-track. In the event it is fast-track then the extent to which it is going to be fast-tracked should also be specified.

- Requirements Of Work

  Requirements of work scan over the basic feasibility of the project units and subunits. The requirements should be properly and clearly specified in the scope statement. The requirements include the overview of basic financial, physical and regulatory constraints. The idea is that by being attentive to these problems very early one can effect a proactive approach.

- Overall Objectives

Overall objectives is the overall functionality which the project is expected to deliver on completion.

- Critical Objectives

  Critical objectives are the minimum desired functionality expected from the project. The fulfillment and approval of these determines whether the project will move ahead or be abandoned.

- Controls Philosophy

  The type of organizational control systems and the policy should be specified.

- Performance Specifications

  The performance specifications of the equipment to be used is to be specified.

- Repair And Maintenance Standards Expected

  Apart from the functionality the quality which the project is to deliver should also be specified by specifying the repairs and maintenance standards.

- Eventual Extensions

  The scope statement should spell out expectations about any such plans.

- Contingency Policy

  The scope statement should include a contingency policy. This policy should be a comprehensive policy in the start including in it the policy for allowances and management reserves. As the process goes on than these can be separately specified.

- Basic Architectural Plan

4.1.3 Initial Scope Document

The sixth step is to prepare the initial scope document. The initial scope document should include

- Description Of Facilities Or Units.

  Detail description of facilities and units should be specified. From which the functionality and detailed requirements of each unit can be ascertained.

- Detail Functionality

  From the detailed description and requirements detailed functionality should be documented. Which serves as input to civil and other engineering disciplines, and establishes the design basis.

4.1.4 Technical Scope Document

The seventh step is the preparation of technical scope document. Technical scope document is, which describes the projects's detailed technical functionality. Technical scope must present enough detail for comprehensive scheduling, estimating, and resource allocation to be reasonably accomplished. It should include

- Basic Drawings
- Specifications
- Facility Layout Sketches
- Facility Design
- Flow Diagrams
- PE&IDs[1] Single Line Diagrams
- Equipment And Instrument List And Their Arrangements.
- Preliminary Estimate And Budget

[1] Plumbing,Electrical And Instrumentation Diagrams

In order to be explicit as to the meaning or extent of various systems, scope may be further described in terms of cost budget figures. Such budget figures need to be expressed in enough detail to provide the basis for a cost control system and for evaluating any subsequent changes to that scope. Any mistake in the estimation process can also become a cause of scope changes whether it falls short of actual expenditure or is an inflated one. If it falls short and no extra funds can be made available then the scope of the project has to be revised. Conversely if it is discovered that there is going to be a large amount of saving. The owner might want to revise the scope to benefit from that saving and in doing so might cause the revised scope to exceed the original cost and have even greater impact.

The recommendation of this thesis is that cost-modeling computer programs should be used instead of conventional estimating methods. The main reasons for using cost-modeling programs is that they give you the flexibility of trying out different scenarios. Once basic input is done changes and revisions can be made with comparatively little extra effort. The human errors to a large degree are eliminated and the modeled estimates tend have less variance with a higher confidence.

- Cost Control Accounts

  The cost control accounts help to monitor and streamline the expenditures and thus help in projecting correct scenarios and therefore cost control.

- Breakdown Structures

  One of the control tools used on large projects is the work breakdown structure work breakdown structures. It breaks the project in hierarchical fashion, the object being to include within the work breakdown structures all elements of work in ever increasing detail. Resources should be allocated to each element of the work breakdown structures to establish a detailed baseline for resource budgeting and control. The work breakdown structures is a vital tool in scope management. If a scope change involves work not previously included on the

work breakdown structures, it can be logically added to the work breakdown structures and its relationship to the other work breakdown structures elements seen. If the scope change only changes requirements associated with existing work breakdown structures elements, this is very readily tracked.

In the conceptual stage proper break up of project into manageable work/project break down structure insures more effective planning which leads to a more complete overall view, more easier detailed project definition and consequently less changes. One of the purposes of work breakdown structures is to develop better time, cost and resource estimates based on smaller elements.

- Quantity Take-off's Of Bulk Items

  The bulks should be estimated as early as possible no matter how little information is available at this stage and how rough is the estimate. The reason is that in the event of unavailability, delay or high cost can result in scope changes.

- Engineering Procurement Plan

  It should include procurement initiation plan on long lead-time, and customized items. This is especially important for the items which are to fabricated, contain especial materials or are to be imported from overseas.

- Initial Master Project Schedule Initial master project schedule should be made to determine the overall project duration and the interrelationships between project phases.

- Special Plans

  Which include plans for obtaining required licenses and permits. The earlier this is done the better scope can be defined which shall conform to all the regulations.

4.1.5 Use Of Computers In Definition Phase

Two major requirements of this stage are, that the scope should be completely defined the other thing is that there should be no faults in the definition. For the definition to be complete the owner should know what his needs are and be able to communicate them to the designer completely and effectively and the designer should understand what the owner needs are be able to guide him to narrow down his options and to fine tune his needs.

As we see in chapter 3 that the most important player at the start of the process is the owner. During the scope definition stage and the most important influences are his needs and the attention. The second most important player is the sponsor and the influence that he can exert is status of the funding or finances and the third most important player is the designer entity, who's most important influence for this stage is experience, knowledge, and the attention. All these influences collectively carve out the initial scope of the project.

The interfaces between the players are always important no matter in what stage a project is. At any specific point of a stage or a phase which ever players are more important, the interface automatically becomes important because of the increase in the information exchange at that interface.

As we see the first step in the conception of a project is the need of the owner. If as a first step in scope management we can help the owner to better define his needs we might reduce the problem of incomplete scope definition, the thing to figure out is to how this to be done. We see that we have to improve the understanding and imagination of the both the designers and owners and the intercommunication between the interfaces. It should be noted as mentioned again and again the owner entity includes the owner or his representatives and that the final deciding authority is the owner. So it his clear that even in the event the owner has a very good team working for him we still need to focus on him. Unless the team has full decision making powers delegated to it which is very rare.

Now let us see how this can be done . One thing that is very trivial and important is to bring to the attention of the owner the problem of scope management .If we could make the owner attentive of the problem he would be more careful in laying out his ideas and be willing to spend more effort in the scope definition process.

The way we can make the the owner knowledgeable about the problem is to make accessible to him the records of scope changes on other projects and their consequences so that he can learn from the previous experiences and plan better for his own project. The point is how to present this information in an understandable form to the owner who might not be that knowledgeable about construction. The next thing is that if in some way we could provide or model of what the owner proposes in a manner, that is, if not readily atleast easily understood by the owner. For this we have to have some means of synthesizing the the needs of the owner and his thoughts and to use some forecasting methods which could project his needs properly and some means to simulate this information to model it.

This can be accomplished by frequent interaction with the owner and using some informative tools to enhance his understanding. The use of computer technology can greatly help in these respects. It can also help to formalize and ease the information flow between the interfaces. Previously the owners could not visualize the end result of there thoughts or abstractions. Historically also, as pointed out in the section 3.4 the owners used descriptions of prior projects and other models to transform the abstractness into reality. In fact the models are still used for briefing purposes. The computer has made this fairly easy and the modeling process takes less time gives much more better results. The computer generated images can be manipulated in lot of other different ways. It gives you the flexibility of trying different styles, backgrounds, and other arrangements and can even show the finishing and decoration details. Any part of the model can be sectioned from any place angle and viewed.

Nowadays the computer aided design and drafting systems have three-dimensional capabilities. The three-dimensional computer aided design systems have been extended by the interactive use of walkthru, a simulation and animation system. Walkthru is an object-oriented system which operates in real time motion under the user's control and orientation' and simulates movement graphically through the designed model. Control of individual objects in the walkthru is a feature which has significant potential as an interface management tool. Walkthru models can be used for architectural purposes. There are soft wares like city design 2000 systems which are basically userfriendly menu driven animation systems. They permit the user to select from various menu options and construct a model. It is fully interactive and has various options ranging from utilities to colors etc.

Basically what computers do is that by synthesizing and presenting the information they let the user to handle more detail. They also give the flexibility of manipulating the information at will and are highly interactive. In very high tech projects different parts of the project can be programmed as objects and a four-dimensional picture generated, the fourth dimension being the time. It really shows the how the pieces will go together and how the project will be assembled. This is very useful for the individuals who cannot understand two or 3-d systems. The next generation are VIRTUAL reality systems. The virtual reality type systems literally puts the user in the design space. In future the sense of smell feel and touch will also be included so that it would provide a real life experience for the owner who can move about in it and decide the changes and polish his needs.

The same technology can be used to demonstrate the feasibility of the project to the sponsor. Various options and scenarios can be generated to predict the change in the profitability and hence reducing the possibility of the backing out by the sponsor at a later date.

4.2 Recommendations For The Modification phase

In the view of the author of this thesis if the procedures described in the previous sections are adhered to then the definition should be ideally complete and there should be no need for modifications initiated by the sponsor or the owner. But as discussed in chapter 3 there might be a need for scope modifications due to the faulty scope definitions and the causes which are unique to the modification stage as discussed in chapter 3. Also there might still be a need for modification because of the owner, sponsor, or the influence of the external factors.

In any case the following procedures and recommendations are presented to step-wise manage the modification stage.

- Scope Change Identification.

  When ever a scope change is initiated first of all it should be identified. Change identification includes the identification of the highest tier of drawings, respective workbreakdown structure/s affected by the suggested change.

- Scope Change Definition

  In change definition as complete definition of the change as possible should be included. By the definition it is meant the details of the components of the change. It can be similar to a preliminary change order format. Describing the items and their estimated rates.

- Impact Calculation

  The impact of the scope change to cost and schedule as well as other areas of the project that may be effected by the scope change should be calculated. While this approach requires considerable effort and paper work, it does force considered thought of every change. Another major advantage is that it forces design engineers to become cost and schedule conscious . On the basis of these impacts the necessity of a scope change should be determined.

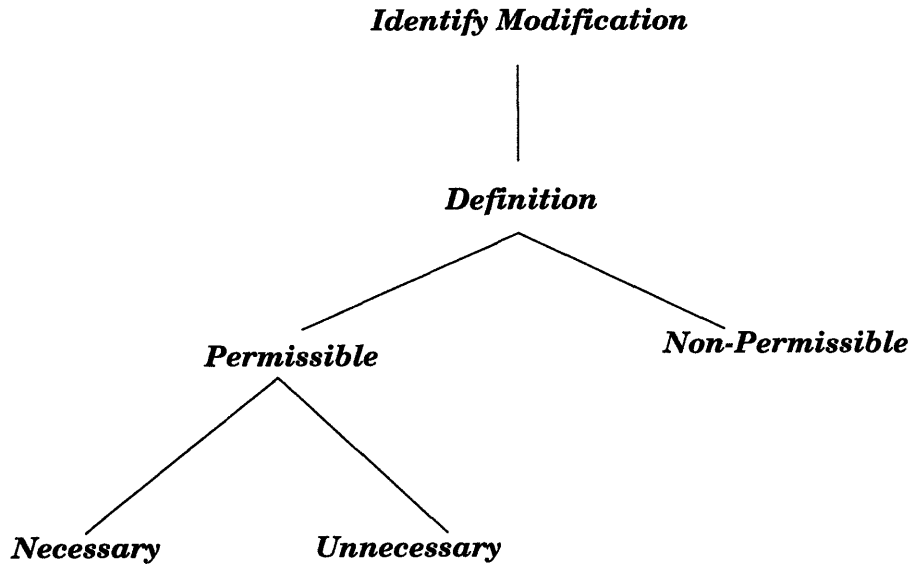

Figure 4-1: Modification Justification

- Justification

  In change justification a brief description of the reason for the suggested scope change should be included. Every change must be justified and reviewed by the designers. In Figure 4-1 the decision at the nodes is taken, taking into consideration the impacts calculated in the previous step.

- Meetings

  The proposed scope change with the justifications and impact statements should then be presented in a scope change meeting attended by the sponsor, owner and the designer. The principal purpose of the scope changes meeting is to present an early assessment and obtain initial approval to proceed with the proposed scope change.

- Change Log

  The modification and the steps and conditions leading to it should be documented for future reference and record. The change log should include the results of the meetings. The decisions taken therein, the descriptions of the

changes as agreed, time schedules, cost schedules and other necessary in formation should be included.

This change log should be updated after every meeting and change. It should also have the tracking data, impact data etc. The reason for this is that this information proves very useful in knowing the status of the current change and decisions leading to it, in the the event another scope change follows the this scope change. It also helps in synchronizing scope changes and the decisions leading to them.

- Designer liaison

  Before starting to work on the designs and drawings of the change in the scope modification stage it is beneficial to have a liaison with the designers during engineering and modification. This improves the communication between the players and remove the misunderstandings and the delay in the information flow which can occur at this interface.

- Disciplinary Control

  In the modification stage there is an almost irresistible urge on the part of technical personnel to continuously improve their design. Left unchecked this could keep a design from ever being finalized. Scope management procedures should manage this urge. One way to successfully deal with this temptation is by frankly discussing the need for resisting untimely design improvements, Convincing personnel of the overall benefit to the project of not making specific suggested changes. In case of personnel whose design is to be revised because of someone else's change can have a demoralizing effect and perhaps lead to reduced productivity, particularly if some of their suggestions have been rejected during the process.

  The recommendation is that the potential scope changes should be reviewed by a select group of senior technical personnel. The leaking of information concerning possible changes should be prevented. Scope changes should be issued to

the engineering groups only after through review, agreement concerning the necessity of the scope change, and complete definition of the modified scope. Any demoralizing effect should be countered by discussing the need for an approved scope change with the personnel impacted.

The effect of personnel adjustments must also be considered. Personnel must be indoctrinated in the use of these procedures whenever they are new to the project or to some critical position within the project. Research has shown that individuals involved in the development and operation of a program will be more committed to its support. Therefore participative management should be effected for increasing management effectiveness.

- Assure Proper Interfaces

  As already pointed out in the previous section different interfaces become important at different points in time. In this case the interfaces that become important are the interface between the owner and the designer and the other interface is between the different design disciplines any flaw in the information exchange between the either of them can become a misunderstanding and further on cause of a scope change. As discussed in the previous chapter, in the modification cycle a lot of information gets exchanged through this interface. It is quite possible these different designers might not be fully horizontally interactive so as to have good information flow between them. This information flow between the interfaces can also be improved by the use of computer technology.

- Specifications

  The specifications to be followed in the scope change if different should be decided upon and set, to be distributed to all concerned designers.

- Design

  A preliminary design should be done.

- Drawings

Based on the preliminary design the drawings should be made and presented with the design and estimate for a review.

- Estimate

  Based on the information of the first two steps an estimate should be prepared and its impacts documented.

- Review impact

  The order of magnitude assessment of the man hours involved. The critical path and schedule impact of the man-hours should be determined and the man-hours for performance adjusted. The resulting assessment should be reviewed by the sponsor and owner prior to proceeding with a scope change.

- Approval From The Owner

  The information of the preceding steps should be presented to the owner and approval obtained from him to go ahead with the detailed design of the modification.

- Approval from the sponsor

  The sponsor should also be briefed on the above information and his commitment renewed.

- Proceed

  In the event of all green signals the detailed design of the scope change should be undertaken.

- Constructibility Review

  A detailed constructibility review should be done on the detailed designs of the modification.

- Safety Review

  The detailed modified designs should also be checked for safety.

- Permit Review

  A scan of regulations and codes should be made preferably by a code consultants to avoid problems later on. The reason of all these checks is that if there is a discrepancy it should be corrected as early as possible and the design made to conform to the requirements. This will reduce the chances of change in scope and a later time.

- Technical Review

  A detailed survey of existing technologies should be undertaken to check for any new release of commercial technology which might be under experimentation at present. The reason for such an exercise is that if the newest technology is to inculcated in the design or in the construction method. The design should be according to it so that the scope may not have to changed later on.

- Alternate Analysis

  During the scope modification process alternate analysis should also be conducted through which either the change can be avoided or a better recommendation made.

- Final Review

  A final review should be made by the owner, sponsor and the designer of the scope modification and the alternate recommendation and final decisions made.

- Refine Detailed Engineering

  Any left-out details should be attended to and detailed engineering refined.

- Modify Construction Work Packages

  The construction work packages should be revised if need be and checked for any disruptions.

- Construction Schedule

  The construction schedule should also be revised and finalized.

- Project Execution Plan

  The overall project execution plan including flow of money and labor details finalized

- Contract Documents

  The contract documents should be completed and tenders invited.

4.2.1 Use Of Computers In The Modification Phase

The first use of computers can be to form data bases for current and historical records of as built drawings and decision logs. These can be used for reference by the designers during modification stage. Computer-Aided Design and Drafting can be used to integrate the design disciplines - including preliminary design and detailed design stages. Electronic representation of project mapping and design, available on local and wide-area networks to project participants, provides a synergy of design optimization and interface management. It can also help in construction planning, analysis of alternative sequencing, constructibility and operability reviews including interference checking.

It can be interfaced with other data like geographical information systems and geotechnical data base management systems to produce graphics such as subsurface profiles, reducing the risks of differing site conditions and thus reducing potential for scope changes.

As discussed in the previous section time-sequenced 3-D graphics plus the forecasting simulations can be used to brief the owners and sponsors of the profile and impacts of the scope change.

4.2.2 Late Modification Stage

In the late modification stage the scope changes usually happen due to the influence of indirect players as discussed in chapter 3 and in some cases from the the influence of vendors or the constructors.

The usual reason for the scope changes due to indirect factors are the regulating permits or litigation with the public. The best way to deal with such situations is to dedicate a portion of the organization. We should create a special cell which should focus on these problems and deal with them preferably through negotiation or patnering.

We see that the most of causes of scope modifications in later stage can be traced back to the earlier phases. So the recommendation is to have this special cell from the start. This part of organization should handle all the external affairs.

Ideally it is function should be as follows

1.. To perform surveys

2.. To function as a liaison office

3.. To deal with the regulatory offices

4.. To promote patnering

5.. To work as a community relationing cell

The surveys would help in collecting and analyzing data pertaining to change in regulations, technology, and the public opinion. As a liaison office it would help in good communication between the outside world and the project organization. The specialization in the regulatory trends and redtape would help in mutual understanding and speeding up the process of approvals and permits. Partnering approach should be adopted for matters that are out of hand. Good legal support should be available in case of break down of partnering.

The public needs to be informed before they get the wind of the things by the rumors and distorted information which they may not understand. The public can be kept informed by intensive community relationing. Such an approach would help in curbing the scope changes which are indigenous to the late modification stage.

In the event the scope change is inevitable in this stage then the same procedures as outlined in the previous section are to be adopted.

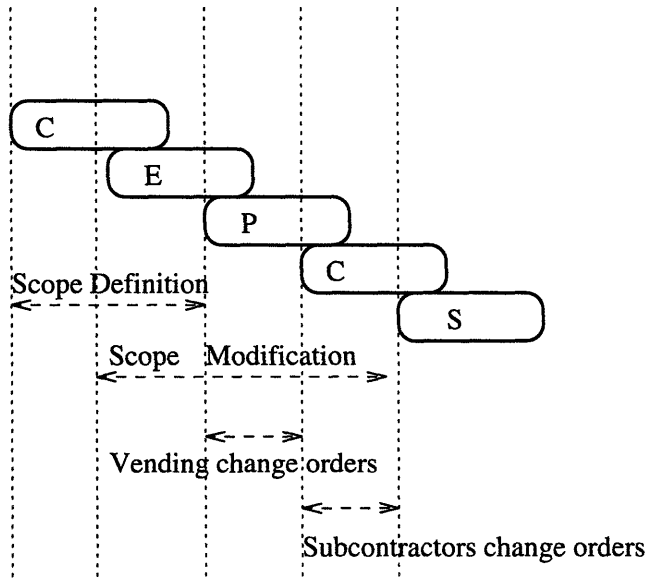

Figure 4-2: Scope Change Impact Stages

4.3 Conclusions

In the Figure 4-2 we see that any modification before the start of the procurement phase does not necessitate change orders and any modification after the engineering phase has a lot more chances of requiring change orders, negotiations, and even one might have to deal with claims. For example if modifications are made in the procurement stage. It calls for making change orders to vendors with which contracts have already been signed. Similarly if modifications are made in the construction phase they become a cause of change orders to constructors.

So the prescription is that " The evil of scope change should be nipped in the bud" or the old doctor's remedy that prevention is better than cure applies here.

As we saw in section 3.1 an omission or mistake horizontal scope definition and the resultant change thereof has a larger impact than a scope change in the vertical direction. Therefore at the very start of the conceptual stage first and foremost attention be given to the definition of overall all scope and the units within it. Also

we saw that since the frequency of vertical scope change is more than the horizontal scope change, after the overall scope has been completely defined the attention should be focused on the smaller units and the detail's definition. In the schedule for most units and subunits there are 3 to 5 major structural activities and then 17 to 18 finishing activities. As the structural activities form the major part of the scope, the effect of scope change is more on the structural activities. Therefore structural activities deserve more attention next priority should be on those finishing activities on whom the the functionality of the structural activities depend. When detailing the size and the type, the functionality that different items and activities are going to provide should be properly specified and checked and rechecked. One should also be very aware of the scope changes which in the start are not contemplated to be scope changes but can become scope changes if proper attention is not focused on them. These changes occur while correcting the faults in the size and type of the changes.

The idea of the thesis was that people are not aware or do not think or perceive that scope changes can occur. Their attention is on the other factors like delays, structural safety finances, interest and profitability. So I wanted to point out that the attention should also be towards scope definition and on scope modification. We should use every method to bring up the mental capability in terms of imagination and understanding level of the players. Especially the improvement in knowledge of the owner and experience of the designer entity.

The procedures and recommendations presented in this chapter will help improve the scope development process by improving the interaction, attention, knowledge, and the experience of the players involved. The improvement in these factors improves the scope definition process by better defining the needs and in the modification process by better attention to details in the process.

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