

# **Total Project Management of Complex Projects Improving Performance with Modern Techniques**

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## **Synopsis**

This presentation deals with the issues involved in understanding and running successful capital projects in terms of Executive control, internal project environment, project management integrative and control functions, project phases, work breakdown structure (WBS) and how they all relate. Key success factors are identified.

The presentation places special emphasis on the importance of forming linkages to the project external environment, and a separate section deals with project management education and professionalism, its basis and importance. Appendices cover construction project management functions, essentials rules for WBS work packages and a short Glossary of Project Management Terminology.

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## 1.0 Introduction

While I was in India last time three years ago, India's Prime Minister, Mr. Rajiv Gandhi, made a most interesting statement. He was addressing the Consultative Committee of Scientific Departments for monitoring progress on four technological missions: Drinking Water; Communications; Edible Oils; and Vaccination and Immunization. He said:

"...strategies must be evolved to achieve results within a pre-decided time-frame, resources should be identified and management methods so adopted that red tapism did not block progress." He went on to say: "...For achieving the mission's objectives, it is imperative that specific time bound tasks are spelled out clearly and allotted to specific institutions for implementing them within that time frame."

Not only was he clearly speaking of Project Management, but I understand that Mr. Gandhi is firmly committed to Project Management.

In 1989, the Ministry of Programme Implementation issued a Manual on Project Implementation. In his foreword to this manual, Dr. P. K. Basu, Secretary to the Ministry, observed that "...most of the projects suffer from inadequacies in project implementation, resulting in huge time and cost overruns, affecting their viability, and thus acting as a drag on the economy. The main reason attributable is the inability to make use of the right management technique or failure to apply the same..."

Therefore, it is very encouraging for me to learn that it is now proposed to set up an Indian Institute of Project Management (IIPM) which will be a non-profit institute of higher learning dedicated to the state-of-the-art in project management through education, training, research and related consultancy.

But I have to alert you to the truth that the problems noted above have their origin much earlier than the implementation phase of a project. Therefore, I suggest that the goal of IIPM might be:

"To be able to identify and develop financially or economically sound projects while conserving human and material resources and protecting the physical environment." and the objectives of the Institute's graduates might be:

"To establish a solid record of (such) projects by managing them successfully from concept-to-operation, through a network of trained, creative and experienced project management professionals. Today, I should like to discuss project management, what it is and why it is so important to have a sound understanding of this emerging professional discipline. Therefore, I propose to deal with three general areas of project management, although time will permit me only to cover each in very simplistic terms.

These three areas are:

- Understanding and running a successful project
- The environment external to the project
- Project management education and professionalism

## **2.0 Understanding and Running a Successful Project**

As projects become larger and more complex, the effective management of them becomes proportionally more significant. For these projects, the consequences of decisions on, essentially, how well the project is to be managed, with commitment to communication and coordination, will generally far outweigh the consequences of how well a specific technical role is performed. The tighter the schedule, the more this need is magnified.

The required skills are thus quite different from the technical design, engineering or construction skills usually associated with most projects. Indeed, on a large complex project there are aspects outside of the scope of these technical areas that have to be well managed, if the project objectives are to be met. For this reason, great emphasis must be placed on the project management team approach, backed by broad based specialized resources.

### ***2.1 The Keys to Success***

The key to the successful management of any large project is therefore highly dependent upon the following:

- A demonstrated leadership through a management organizational form capable of providing effective planning and management
- The use of a project management system as a model for management philosophy and strategy
- The use of proven, contemporary project management theory and practice in planning, organizing, leading and controlling the use of project resources

In the last analysis, the test of effective project management is the degree to which the project objective has been accomplished on time and within budget to the satisfaction of the "stakeholders".

This means working with people to achieve results. This is especially true of highly technical and complex environments such as those involving modern day construction projects. Consequently, it is essential that the project manager and his team are sympathetic to, and comfortable with, their cultural and organizational environment. Therefore, let us first consider the traditional corporate management environment.

### ***2.2 Traditional Corporate Management***

Traditionally, management education has not been concerned with projects but with the running of an on-going enterprise. Time is not an immediate concern. Change is minimal and protracted, and hence can be thoroughly programmed and progressively integrated. The work places of such enterprises are bounded by traditional hierarchies, lines of authority, centralized control and repetitive, assembly-line type jobs.

Unfortunately, this traditional corporate management approach breaks down where projects are concerned. Consequently, new management relationships are required, which tend to cut across the normal flow of authority and responsibility and radiate out side of the functional unit. Happily, project

management is a much more exciting and challenging work environment, even though a clear understanding of its concepts is relatively new.

This is because Project Management is a *different* type of management applied to project-type work. However, associated with almost all capital projects are many people who are not trained in the process of bringing a capital project on stream. Without embarrassment, I include politicians, owners, sponsors, financiers, bankers, operators, lawyers, accountants and, I regret to say, even engineers.

Thus, it is essential to establish competent Project Management capability long before even putting in place appropriate design, engineering or construction capability. But first let us understand the project manager's organizational environment.

### 2.3 The Project Manager's Organizational Environment

Typically, the project group to be managed will consist of consultants, contractors, specialists, the staff of the owner and the project control team itself. A typical situation is shown in Figure 1. Each unit or person in the group has two allegiances or "bosses", the project manager and his "home" department or firm. This dual reporting relationship is often referred to as a "matrix" structure and accounts for much of the complexity of project management on a large project.

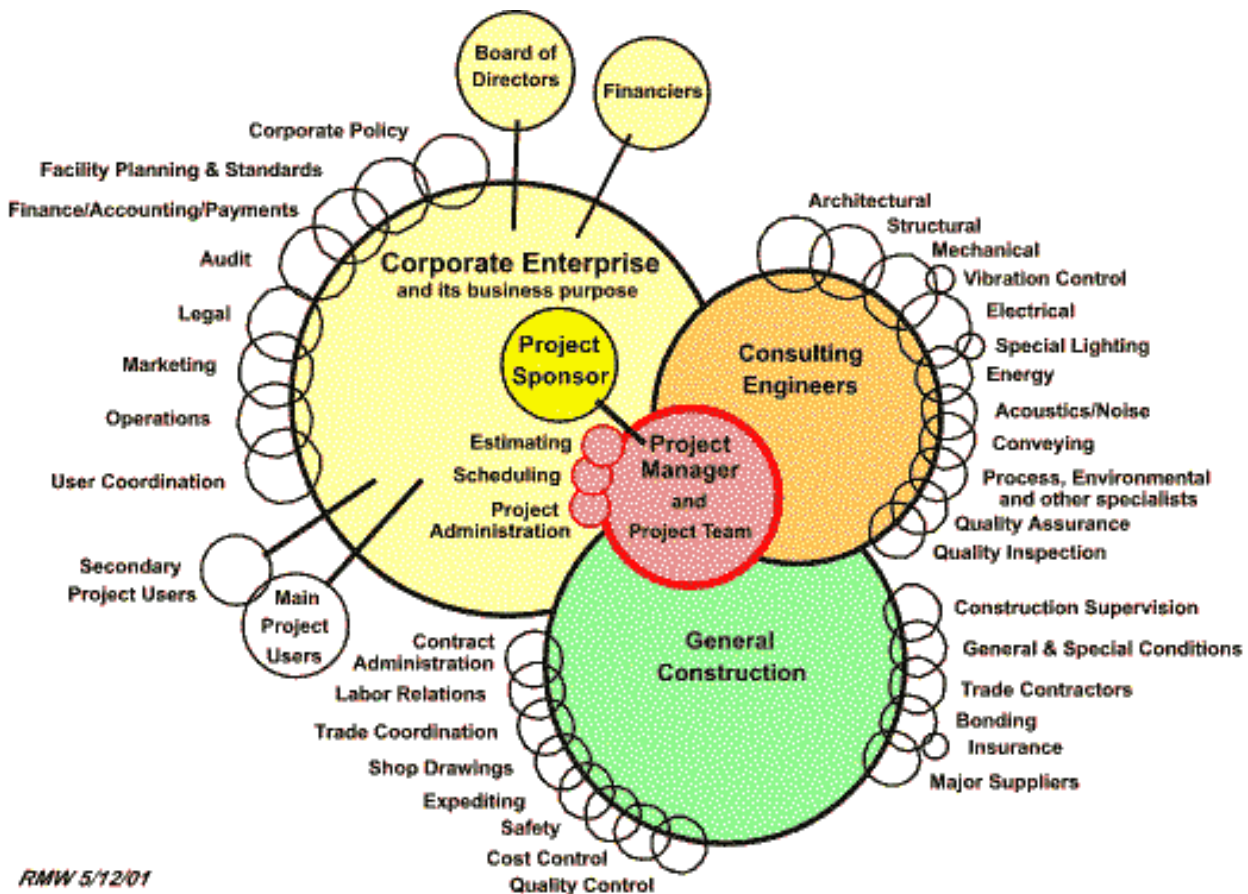


Figure 1 Project management in a corporate environment

Ideally, the project manager will receive an "Authority" or "Mandate" from the project's "Executive", i.e. the party that has the authority to approve further project funding. This mandate should be to direct all operational activities including planning, design, procurement, construction and commissioning. As such, he will have requirements for such project support activities as estimating, forecasting, scheduling, procurement, project accounting, and progress reporting.

In addition, on a larger project, he will require other more specialized services such as financial accounting, payroll, systems development, personnel, legal, public relations and property acquisition. Because they do not normally affect project control decisions, these activities are usually carried out by independent departments or companies, not under the project manager's direct supervision. Nevertheless, if the project manager is to get the quality of information and service that he needs, he must maintain good communications with all such parties.

The project manager will also be required to report to the Executive on a regular basis. For this he must render a succinct digest of the available information on progress, forecast, resource requirements, and actions required.

In contrast, the Executive's interest will tend to focus on expenditure to date, forecast final cost, and the scheduled commencement of the facility.

### 2.4 Project Phases

As shown in Figure 2, there are four distinct project periods which make up the typical project life span.

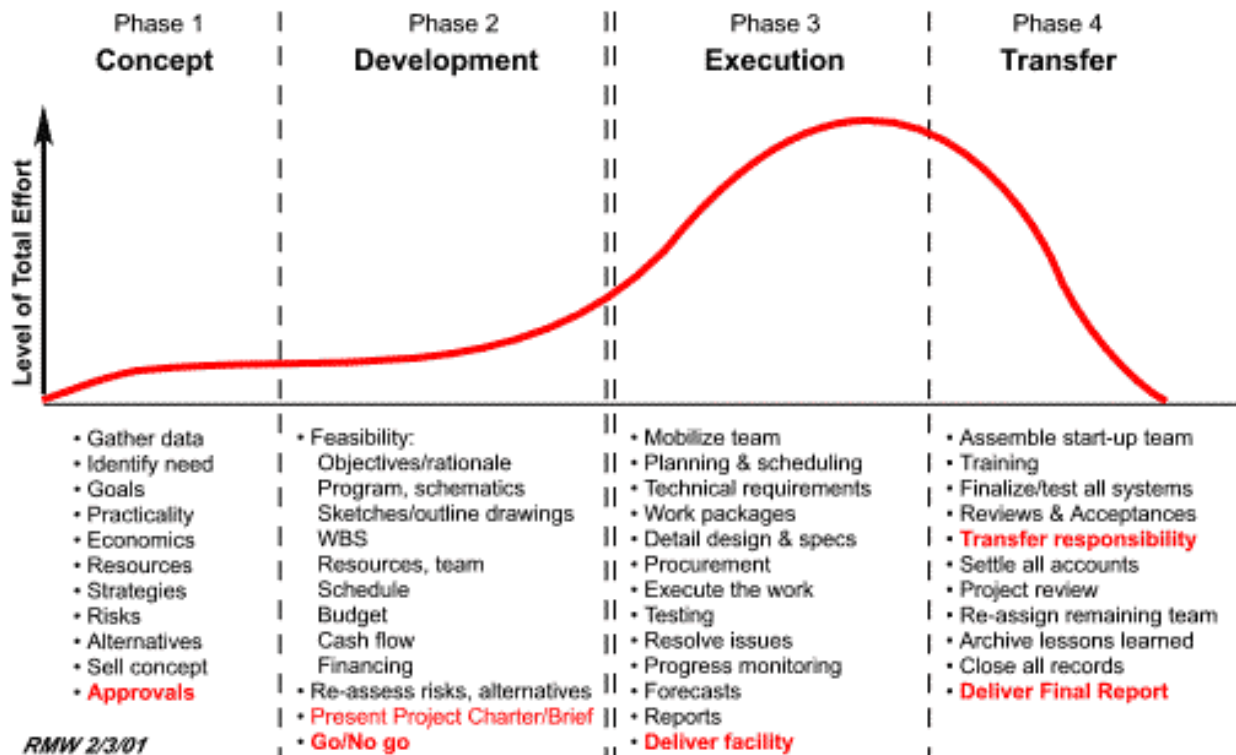


Figure 2 Project Life Span: Four Basic Periods

These four basic periods are:

- Concept - for developing the project parameters in outline
- Development - of the plan and design and definition of the facility
- Execution of the plan
- Transfer of the completed facility over to operations.

These periods or phases may be more easily remembered by the letters **C-D-E-F** standing for: **C**onceive **D**evelop **E**xecute and **F**inish.

Figure 2 also shows typical activities which are required in each phase for building, say, a hydro electric facility or a process plant. Of special significance is the variation in the level-of-effort (LOE), which is associated with these activities, and which is required to conduct a project through its life span. Note especially that "approvals" are called for at the end of each of the first two phases. These are really like "gates" between major phases of the project, also known as "major milestones", or "Executive Control Points".

### 2.5 Executive Control Points

Every project should have Executive Control Points acting like closed gates which only open following Executive Approval, see Figure 3. At these points, the project manager presents certain predetermined "deliverables" to the Executive that will enable them to make an informed decision on a "go" or "no-go" basis for further work.

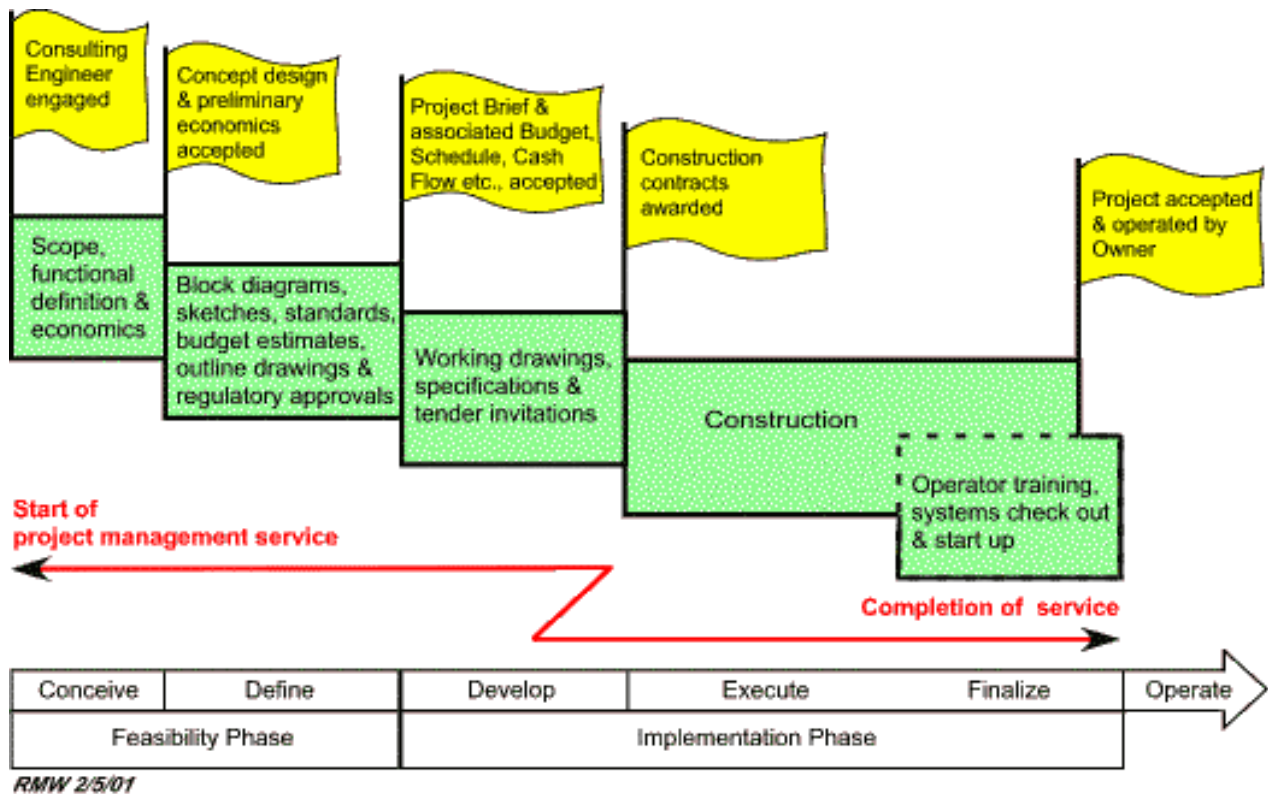


Figure 3 Project Life Span Control Gates



It must also be emphasized that it has been estimated that it costs about ten times as much to implement a change in each succeeding phase. Hence, during construction, changes (and consequent delays) will cost ten or more times as much to implement, compared to making the same changes during the planning phase.

Therefore, these points provide the opportunity for the Executive to exercise a high level of control over the shape and timing of the project. The Executive can thereby ensure that either the project is developing in a manner consistent with their objectives, or the project can be modified with minimum upset if the objectives have changed. It is also the opportunity for the Executive to provide a morale boost by injecting enthusiasm, excitement and discipline into the project team.

Equally, these formal approvals provide the project manager with his authority to drive the project through to the conclusion of the ensuing phase. It is also his opportunity to ensure that the Executive is behind him and that he is proceeding in the right direction.

Undoubtedly, the most important control point in the project life cycle is reached at the conclusion of the development phase because this marks the project's transition from feasibility to implementation. At this point, a project "go" decision must be based on sound and well documented information. This information should be presented in a comprehensive document referred to as the Project Brief. It is the means whereby the Executive know precisely what they are getting.

## ***2.6 Project Brief***

The Project Brief, when approved, becomes the prime source of reference for the project implementation phase. A good Project Brief will include:

- Executive summary
- General statement of business aims and objectives
- Technical approach
- Statement of project scope
- Regulatory approvals and requirements
- Preliminary design sketches, block diagrams, standards; o project team organization
- Implementation schedule
- Procurement plan
- Project estimate and proposed appropriation budget
- Other resources required from the sponsoring organization (e.g., land, space, staff, etc.)
- Financial statement and economic projections
- Cash flow projection
- Justification, alternatives; and
- Areas of uncertainty and risk.

## ***2.7 Project Management Functions***

The management functions involved in a project typically include scope, quality, time, cost, risk, procurement of human and material resources, and communications management. Each represents a

separate discipline calling for special training, and the requirement for each function depends on the size and nature of the project in question. These functions are now considered to be part of the "Project Management Body of Knowledge" or PMBoK as it is called, as developed by the Project Management Institute.

This subject is discussed in rather more detail in Section 4.0. A copy of the PMBoK is available from the Project Management Institute, in Pennsylvania, U.S.A.. However, the functional descriptions given in Appendix A will be more familiar to construction people.

## ***2.8 Project Control Cycle***

The basic cycle of management control can easily be remembered by the mnemonic "POEM" standing for: **P**lan, **O**rganize, **E**xecute, **M**onitor-and-control.

**Plan** - The first step is to plan the project with respect to scope, quality, time and cost. What precisely is to be done? Why? If it is, say, a new plant, what is the purpose and process in the plant? How is the job to be done? Why should the project be done one way rather than another? Indeed, why should it be done at all? Where is it to be built? Who will design and construct it? What resources in terms of materials, manpower, finances and time are required? What risks are involved? What strategies are required to deal with unplanned occurrences?

**Organize** - The second basic step is an extension of the first. A careful analysis must be made of the various activities required in planning and executing a project, to provide a closely related project team structure. For every project activity (e.g. programming, estimating, design, planning, procurement, construction) there must be a very clear definition of who is responsible, and who has the authority to execute that activity. That person must also have a very clear idea of its scope, quality, time and budget.

**Execute** - The methods by which the Plan is executed or implemented are critical. No project manager (or other member of the project team) will be successful unless he understands the basic needs of human beings, their strengths and weaknesses, mental and social abilities, and how to weld a complex mixture of humans into a dynamic and productive team. The single most important characteristic of a successful project manager is his ability to manage people.

**Monitor and Control** - Continued monitoring, reporting and forecasting must take place during project implementation, and the forecasts compared to the Plan. Deviations must immediately receive management attention, either by reallocation of resources or modifications to the Plan (with Executive approval if the project objectives are affected). Without a detailed Plan, there is no baseline for comparison, no determination of deviation, and hence no satisfactory basis for corrective action.

Clearly then, a successful project management system is one which monitors and responds by a control action as early as possible after an event. Figure 4 shows the elements of a project control system.

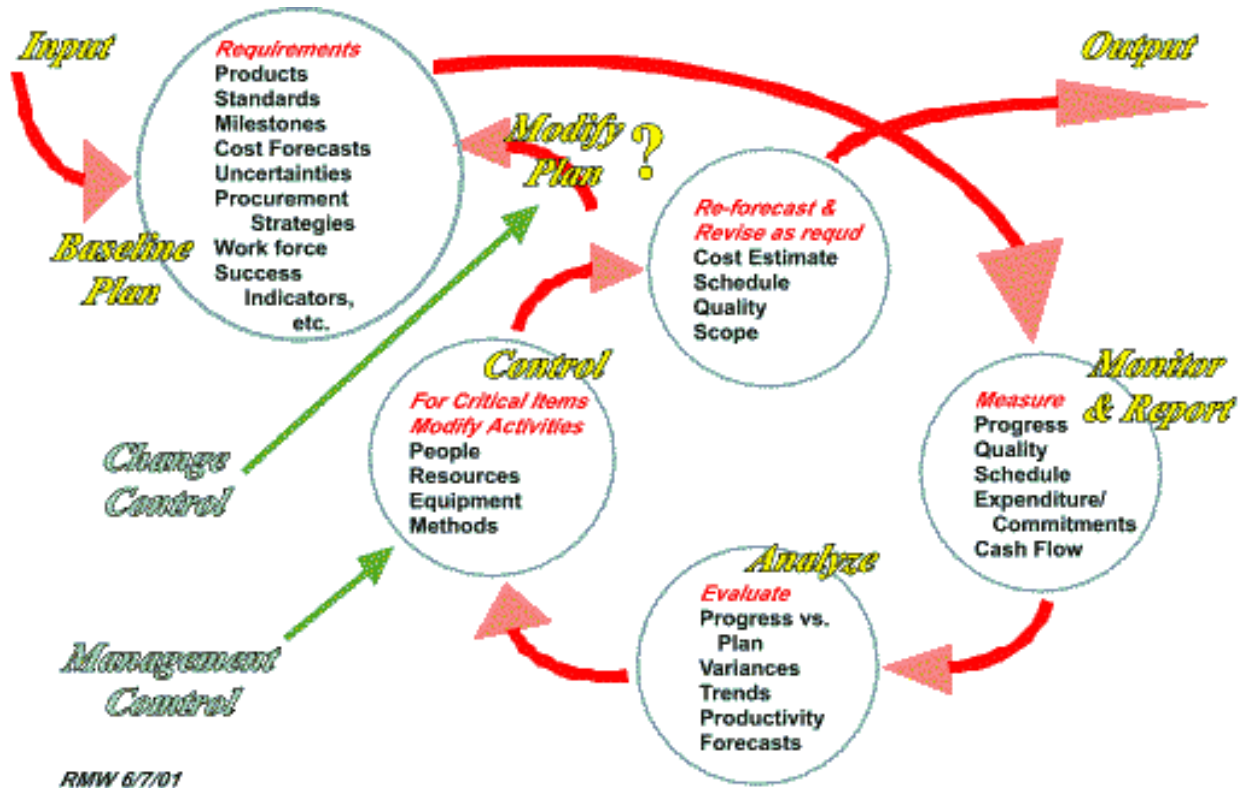


Figure 4 Elements of a project control system

### 2.9 Function-Process-Time Relationship

The relationship between the functional components, the control process and the project phases may be viewed as three-dimensional. This relationship is shown in Figure 5.

The project life cycle is shown on the X axis with its classic four generic project phases, together with the typical variation in level-of-effort with which they are generally associated. On the Y axis are the major project functions to be managed, which in fact I believe apply to *any* project, although they may vary in importance according to the field of application (industry). In other words, if project management is not paying attention to each and every one of these, then they are not so likely to get the best out of the project. On the Z axis is shown the traditional high frequency input-process-output-feedback control cycle.

The point is that this control cycle has to be applied to every one of the major functions as each of the latter are progressively "managed" through the project life cycle in order to reach the project's goals and objectives successfully.

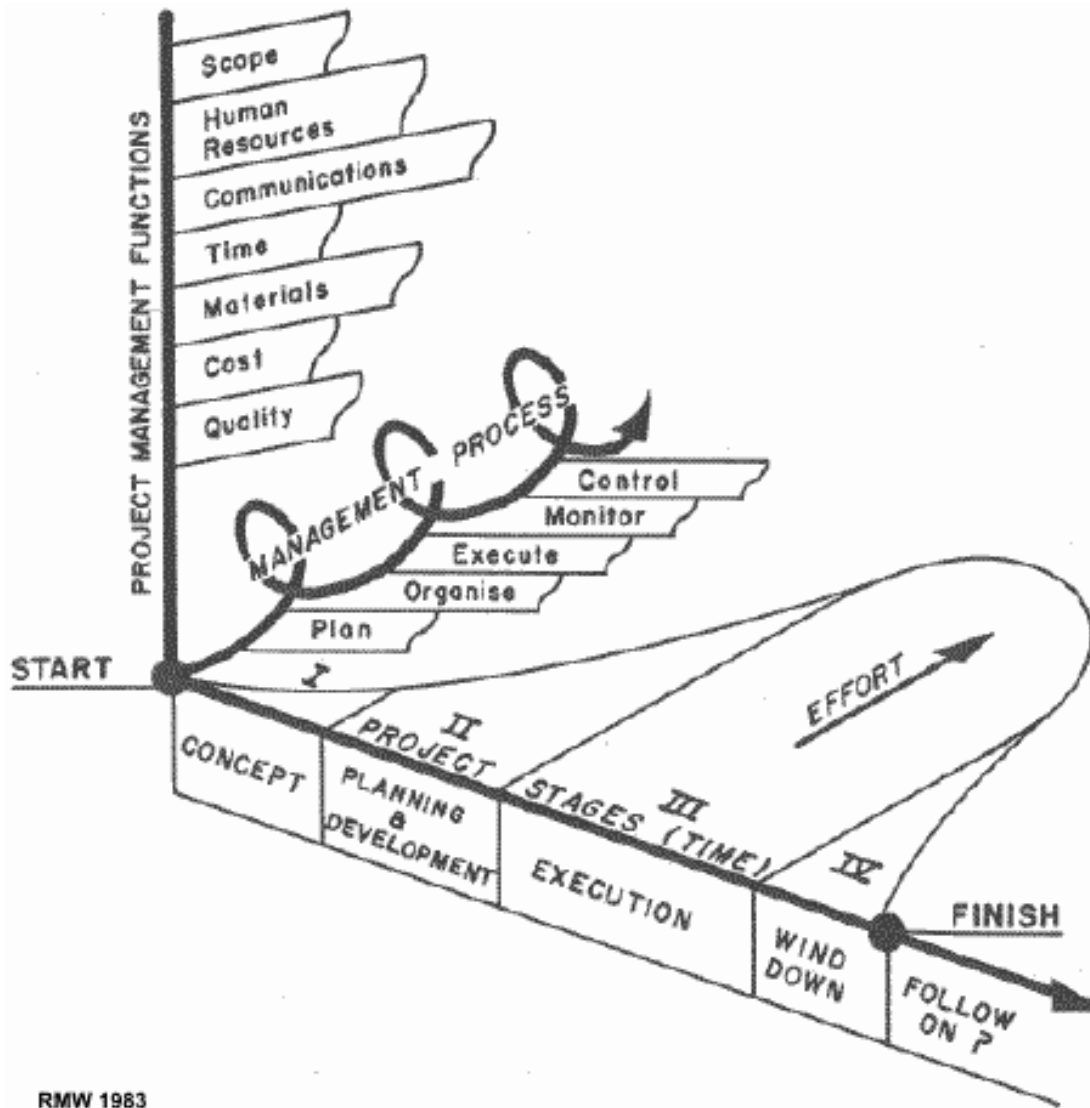


Figure 5 The Function-Process-Time relationship

### 2.10 Project Manager's Objectives

It follows from the foregoing that the Project Manager's personal objectives must be to:

- Attain the willing commitment of people to assigned tasks
- Achieve the coordination and collaboration of different work groups, responsibility centers, and entire organizations, including those of the owner
- Achieve cooperation by placing a high premium on reliability and timeliness of information, and by discouraging unnecessary or irrelevant information
- Steer the project to completion in an orderly and progressive manner
- Ensure that trade-offs between scope, quality, time and cost are satisfactory and acceptable, and are seen to be so, and
- Encourage the development of personal and professional skills amongst the project participants

### 2.11 Work Breakdown Structure

The process of project control described earlier requires the establishment of a firm base line defined in terms of scope, quality, time and cost on a compatible basis, and in units that can be more readily handled. One of the more important and powerful techniques for managing a large complex project, therefore, is the Work Breakdown Structure (WBS), which greatly facilitates control.

A Work Breakdown Structure (WBS) is a task-oriented "family tree" of activities, which organizes, defines, and graphically displays the work to be accomplished.

By means of a WBS the scope of the project can be broken down into a suitably coded structure that identifies manageable segments with clearly assigned responsibilities. See Figures 6a, b, and c for a typical example.

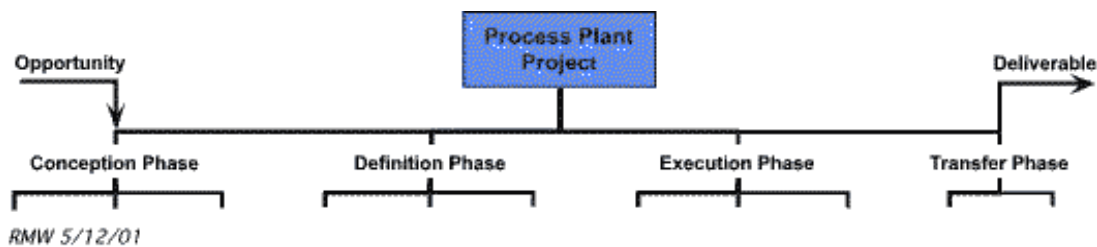


Figure 6a Top level of a process plant project WBS

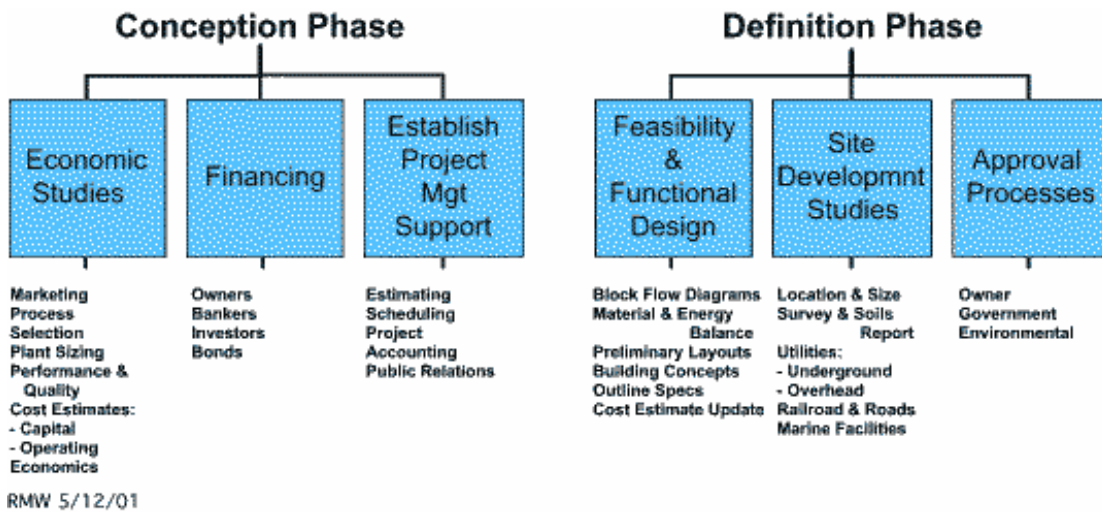
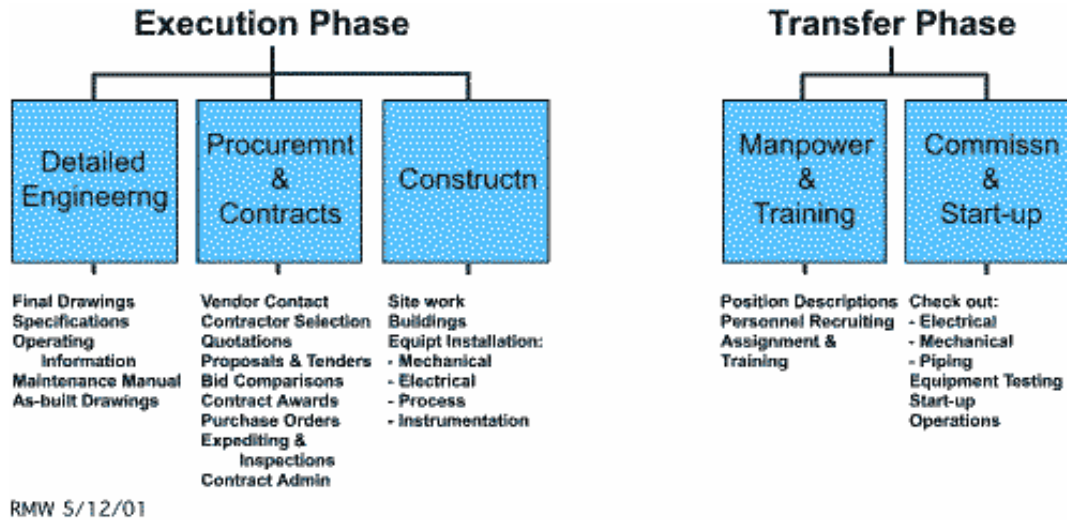


Figure 6b Detailed WBS for the Conception and Definition phases

To be effective a WBS must:

- Establish an information structure for describing the project's scope in entirety
- Serve as an effective means of communication to integrate the objectives and activities of all the internal and external organizations involved in the project
- Represent the planning of the project, step by step
- Separate sequential and parallel activities assigned to different groups who will schedule, measure and control their own performance, and
- Reflect the procurement strategy during the various stages of the project's life cycle



**Figure 6c Detailed WBS for the Execution and Transfer phases**

In practical terms this WBS and corresponding coding also requires:

- Early implementation
- Flexibility and expandability
- Universal application
- Simplicity, and
- Capability of summation.

The "manageable segments" of the project referred to above, are called Work Packages. Thus, a Work Package describes the work to be performed by a specific organizational unit, and serves as a vehicle for monitoring and reporting on progress, cost and schedule. See Appendix B for essential rules.

All work packages fall into one of three different categories, namely:

- Discrete Tasks which have a specific end result or objective. These normally cover 60 to 75 percent of the total work in a project.
- Apportioned-effort Tasks which can be directly related and apportioned to discrete tasks. Examples include quality control or inspection. These tasks are required in support of the discrete tasks, and hence, their schedule and budget can be related to the discrete tasks.
- Level-of-effort Tasks which have performance standards rather than specific end results. These consist mainly of the overhead accounts, e.g., management, administration, liaison, coordination, etc. These tasks are characterized by relatively level, time-phased budgets and are not time-limited as in the case of the discrete tasks.

### **2.12 Prerequisites for a Successful Project**

The Project Executive has a vital role to play and should insist on the following:

**Executive Support** - The Executive must clearly demonstrate support for the project management concept by active sponsorship and control.

**External Authority** - The project manager must be seen as the authoritative agent in dealing with outside parties, and be the responsible and single formal contact with them.

**Internal Authority** - The project manager must have the necessary managerial authority within his organization to ensure response to his requirements.

**Commitment Authority** - The project manager should have capability and authority to control the commitment of funds within prescribed limits.

**Competence** - The project manager and his team members must be competent. Other functional personnel assigned to the project must also be competent.

**Project Team** - The project manager should have a say in the assembly of his project team, which will help him to obtain their personal commitment. The private sector should build up the best source of expertise.

**Project Manager Involved in All Major Decisions** - No major technical, cost, schedule, or performance decisions should be made without the project manager's participation.

**Management Information Systems** - Effective project management information and control systems must be in place, preferably with third party observation, scheduling and estimating resources.

While the foregoing do not necessarily guarantee success, their absence will certainly make success more difficult to attain.

### **3.0 The Environment External to the Project**

Events external to the project often come as a surprise to the project team and are therefore seen as obstacles to progress. However, projects generally exist only because of that external environment. Hence, it is most important for the project team to recognize that they must be responsive to it.

#### **3.1 The Project Manager's External Responsibility**

The project manager's job is not confined to controlling events within his or her own project organization. Equally important - often more so to achieve a successful project outcome - is the need to track the project's linkages to the external environment. This is particularly true of "infra-structure" projects which place emphasis on "development" and innovation and must respond to increasingly rapid change.

It is not sufficient to think of project management as simply the monitoring of time and cost by planning, scheduling and resource leveling, as many software programs might have us believe. Nor even is it sufficient to include the many other organizational tasks of the project manager, as leader of the

project team. Vitally important as all these things are, these are not sufficient for effective and successful project management in today's dynamic world.

The reason is because every development project exists for a purpose relating to, and within, its surrounding environment. It is convenient to refer to this environment as the project's external environment, as distinct from the project's internal organizational environment.

### ***3.2 The External Environment***

What is this project external environment ? It includes the established and latest state-of-the-art technology in which the project is based, its customers and competitors, its geographical, climatic, social, economic and political settings, in fact, virtually everything that can impact its success. These factors can effect the planning, organizing, staffing and directing which constitute the project manager's main responsibilities.

This external environment represents a complex set of inter- dependent relationships, which constantly react with the project as it is brought into reality. Conversely, most projects are intended to impact the environment in one way or another, and this is particularly true of infrastructure projects. Therefore, for the project to be ultimately successful, these inter- dependencies must be taken into account.

Even more important, the factors noted above have a habit of changing during the life of the project, especially if the project takes a number of years to complete, and is brought on- stream in phases. This constitutes a high degree of uncertainty or risk involved with the project, as a result of its external environment. In fact, the greater the degree of interdependence, the greater the degree of uncertainty, and the greater the challenge for the project manager and his team.

Clearly, the environment will not be the same for every project. In fact, it is likely to be determined principally by three considerations, namely:

- The product or service resulting from the project
- The technology and the manner of its application, and
- Its physical location

Thus, to identify potential difficulties, assess their probability of occurrence, and to try to solve them in advance, the project team must learn to interact frequently with those individuals and institutions which constitute the most important elements of the project's external environment. Together with the project's sponsors, owners and users, these people constitute the project's direct and indirect stakeholders.

### ***3.3 The Project Stakeholders***

One technique for dealing effectively with this situation is to prioritize the required stakeholder linkages by conducting a stakeholder analysis. Such an analysis would be designed first to identify all the potential stakeholders who might have an impact on the project, and then to determine their relative ability to influence it.



Potential stakeholders may be thought of in the following categories:

- those who are directly related, i.e. suppliers of inputs, consumers of outputs, and regulators of the process
- those who have influence over the physical, infrastructural, technological, commercial/financial/ socioeconomic, or political/legal conditions
- those who are hierarchical such as government authorities at local, regional and national levels, and
- those individuals, groups and associations, who have vested interests, sometimes quite unrelated to the project, but who see it as an opportunity to pursue their own ends.

### ***3.4 Stakeholder Categories***

Having identified the various stakeholders, each may be assigned to a category according to their relative ability to influence the project. There are three categories, namely:

- Those who are controllable
- Those who are influenceable, and
- Those who need to be appreciated

Within each category, each stakeholder may then be further rated by degree of importance according to their ability to influence the project. Members of the project team can then prioritize their efforts accordingly, and maintain appropriate external linkages, to arrive at the best chances of ultimate project success.

## **4.0 Project Management Education and Professionalism**

### ***4.1 Change and the Need for Professionalism***

The idea of establishing projects, and the consequential need to manage them, has been around for a very long time. In fact, since early civilization major projects like the pyramids of Egypt, or the Great Wall of China, or more recently, the Suez and Panama canals, have been successfully implemented. In their day, these were prolonged and complex undertakings and no doubt exhibited many of the "management difficulties" experienced in today's environment.

The essential feature of these projects, indeed of any project, is to bring about change. That projects are designed to implement change is not new. What is new is the rapidity with which change is currently taking place, and which we may confidently expect to continue to take place.

Project management is a very dynamic, challenging and exciting work environment. However, by the same token others may perceive it as threatening, it is much more difficult to control and is indeed open to misuse and abuse. Today, there is increasing recognition that to bring about progressive and beneficial change successfully, special management skills and understanding are required.

This makes a good case for establishing professionalism in the management of projects, and

practitioners in many fields of project endeavor, and around the world, are actively discussing the possibility of formally establishing project management as a recognized profession.

In the following discussion, special terms used in project management, especially for educational purposes, are shown in bold italics. They can be found in Appendix C, Glossary of Project Management Terms.

#### ***4.2 What is Project Management ?***

In the view of the Project Management Institute ("PMI"), a non- profit organization based in North America and dedicated to advancing the state-of-the-art in project management, the definition of ***Project Management*** is:

"The art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participant [stakeholder] satisfaction."

Special attention should be given to the word "satisfaction". PMI believes that this is a key ingredient of successful projects. That is to say, a successful project is one in which all the stakeholders feel equally good about the end results.

Even more basic to the term project management is the word ***Project*** itself. As noted earlier, unlike the relatively steady state of an on-going enterprise, a project has some distinctive characteristics of its own. Generically speaking, a project seems to be "Any assignment which will end when a goal is reached."

The point is that a project is not an on-going activity. Rather, it is an undertaking that ends with a specific accomplishment and the product or end result is a distinguishing characteristic.

In practice, the work to be accomplished on most projects is constrained by the limited availability of resources. Therefore, again in PMI's view,:

"A project is any undertaking with a defined starting point and defined objectives by which completion is identified. In practice most projects depend on finite or limited resources by which the objectives are to be accomplished".

Note that projects are not limited to a particular field such as construction. Nor is there any reference to size. In fact the word "project" has come to be a household word in the English language. It is a simple concept that leads to a dramatically different approach. It is the difference between maintaining the on-going and creating something new.

The function of project management is, of course, the whole process of managing a project.

#### ***4.3 What is Professionalism ?***

Since the late 1970's, there has been a significant effort by members of PMI to develop project

management into the newest of recognized professions. This presumes that there is indeed a basis for a professional discipline. By examining such professions as accounting, engineering, law, medicine and so on, a study by PMI established that there are five attributes that are generally associated with recognized professions. These are:

- **A Unique Body Knowledge** which implies the existence of principles and concepts that are unique to the particular profession, and which can be codified and documented so that they may be studied and learned through formal education.
- **Standards of Entry** which define the minimum levels at which one commences a progressive professional career path.
- **A Code of Ethics** which makes explicit what is considered to be appropriate behavior and provides a basis for the self- policing of unprofessional behavior, and thereby limiting the necessity for direct legal controls.
- **A Service Orientation** reflecting an attitude by which members are willing to commit their time, money, and energy in attending conventions, publishing their ideas and experiences, and generally contributing to the body of knowledge and its dissemination for the betterment of both the public and the profession itself.
- **A Sanctioning Organization** which sets and promotes the standards and acts as the self-policing agency.

#### ***4.4 The Body of Knowledge Structure***

Clearly, the identification of a unique body of knowledge provides the foundation for the remaining attributes of a profession. In developing a ***Project Management Body of Knowledge*** (PMBoK), early work by PMI practitioner and academic study groups quickly established that a systematic model/framework/structure was needed to meet the requirements outlined above. Moreover, the characteristics of such a framework must be comprehensive, compatible, logical, saleable, simple, systematic and understandable.

Some might say that all PMI has done is to borrow heavily from corporate or traditional management principles. To some extent that may be true, but the big difference is the environment in which a project takes place.

This project environment includes the whole business of establishing temporary organizations; identifying discrete goals and objectives; obtaining commitment to those goals, often in the face of conflicting personal goals; allowance for "learning curves"; and then when the goals have been met, the problems of disbanding in an orderly fashion, with benefits rather than damage to those involved.

PMI studies found that there is a logical five level hierarchy or breakdown within the PMBoK, which reads from top to bottom as follows:

Function → Process → Activities → Tasks → Tools and Techniques.

At the top level there are presently nine areas of concentration or learning. These consist of the four now traditional core functions of managing **Scope, Quality, Time** and **Cost**, plus four integrative functions of managing **Risk, Human Resources, Contract-Procurement**, and **Communications**. In addition, an overview or **Pm Framework** subject area is necessary to tie them all together.

It is the very identification and on-going analysis of these knowledge areas which establishes the PMBoK. The breakdown of each of these **Pm Functions** into processes, activities and so on, provides a comprehensive and unique body of knowledge.

A project manager who is not paying at least some attention to all of these PM Functions on his or her project is probably not getting the best out of the project team! The difficulty is that there always seem to be a number of people involved who do not really or fully understand the process, or who become more interested in the process than the end results.

It is convenient to represent the PMBoK as a matrix which provides flexibility in describing the various functional inter-relationships. However, the **Function Chart Structure** contained within each of these functions is presented as a **Work Breakdown Structure**.

#### **4.5 Project Management Control Functions**

Many texts have been written about both traditional and project management. Doubtless many more will be written as our understanding continually advances. Here, therefore, we can only touch on some of the basic reasons for including the present range of functions within the PMBoK Standards.

The definition of the project's objectives together with all the activities involved in their achievement, and the resources consumed, is known as the project **Scope**. Since the scope of a project has the habit of changing during the life of a project, this gives rise to the need for **Scope Management**.

Not everyone is familiar with this word "Scope". Scope means the work content and finished "products" for which the project has been designed. Sometimes scope may be represented by a statement of the results or performance expected, leaving the content details to the designer. Similarly each phase content, component or Work Package (discussed in Section 2.11) also have associated scopes.

Scope is the definition that describes the project's complete product or deliverables. A scope statement should be introduced by a brief background to the project, or component, and the general objective.

For a project to be considered effective or successful, certain standards of **Quality** must also be stated or presumed. Establishing and maintaining these standards during the life of the project leads to the need for **Quality Management**.

Since a project is determinate, it is clearly set in the context of a finite period of time. Unfortunately, time is a completely inflexible resource, so that activities must be carefully planned and scheduled. This is referred to as **Time Management**.

Because in our society "time is also money", money is a closely associated resource. Fortunately it is somewhat more flexible. Nevertheless, it too needs careful managing, so we have **Cost Management**.

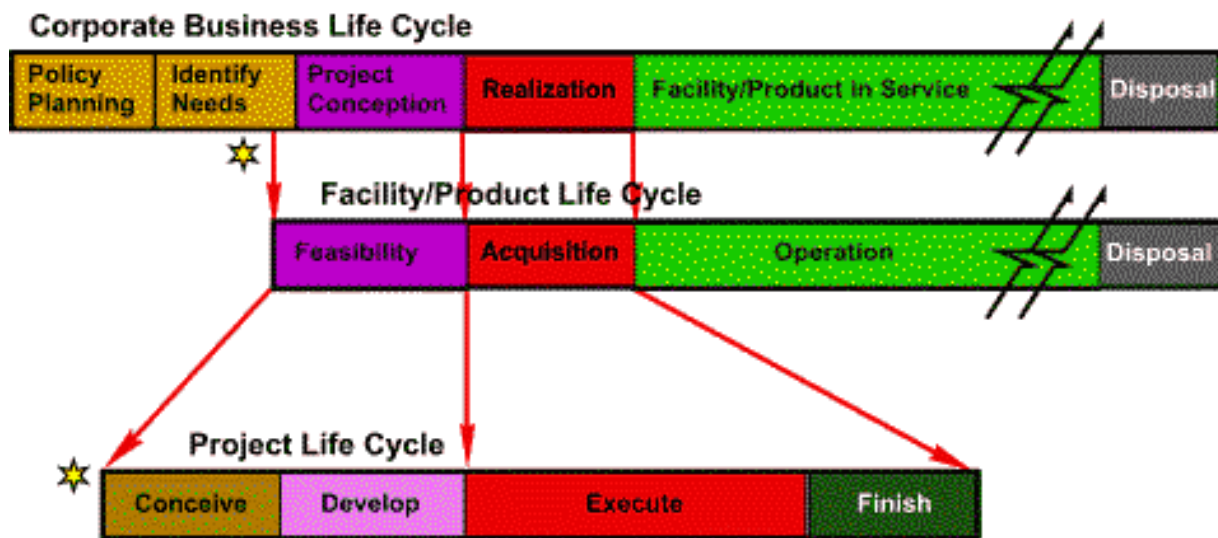
Scope, quality, time and cost management form the core group of project management control functions. However, as yet we have not discussed some of the special circumstances which arise in the management of projects.

#### 4.6 The Project Life Cycle

Through the work of PMI contributors, it has been reasonably established that every project, generically speaking, passes through four distinct and sequential periods or **Project Phases**. These are known collectively as the **Project Life Cycle**. Individually and according to the area of project application, these four phases may be known by different terms, for example: Concept, Development, Execution and Finishing.

As noted in Section 2.4, this happens to be my preference because the sequence C-D-E-F is very easy to remember. Others may use successively terms such as Initiation, Planning, Implementation and Termination or Commissioning or Transfer. For any given project, these phases are typically subdivided into shorter periods or "stages". That is, **Project Stages** are subsets of phases.

This project life cycle should not be confused with facility/product life cycle or even corporate business life cycle. It is of course related to these other life cycles and these relationships are shown diagrammatically in Figure 7. It should be noted that the project life cycle is only a small but vital part of a product's life cycle which in turn is "owned" by the sponsoring organization, which has an even longer life cycle.



★ In the project's Concept Phase, helping to identify the real needs is vital to the project's eventual success!

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**Figure 7 Typical Project Life Cycle compared to Facility/Product and Corporate Business Life Cycles**

To achieve any kind of output or product, an **Effort** is required. In the case of a project, however, the relation between effort and time is very distinctive. To visualize this relationship, consider a curve of effort plotted against time. Clearly the effort starts at zero (before the project has commenced) and ends at zero (when the project has been completed).

In between these two points, the effort-time curve invariably has a very characteristic profile. This may be likened to a pear sliced neatly down the middle, one half of which rests flat face downwards, with the stalk at time zero. The vertical profile is then typical of the time-effort relationship.

Thus, the time-effort curve starts to rise up in the concept phase, tends to level off during development, rises again sharply to a high peak during execution, and then even more rapidly drops to zero in the finishing phase. This typical profile is shown in Figure 2.

This phenomena is fundamental to the concept and needs of project management. The rapidly changing situation depicted by the time-effort curve through the project life cycle places special emphasis and requirements on a number of areas of otherwise traditional management science. For this reason, these areas are considered to be essential knowledge for the effective management of projects.

#### **4.7 Project Management Integrative Functions**

Projects are achieved through people by calling upon their respective skills and abilities. This is why we need the project management **Integrative Functions**.

For example, the number of people and their types of skill varies considerably during the project life cycle. And their collective level of effort varies considerably as we have already seen. Consequently, many of these people are required only for relatively short periods of time. Normally there will be a core group referred to as the **Project Team**, led by a **Project Manager**, but even this team is required only for the life span of the project.

Thus, careful attention must be given to the assembly of people working together effectively through a clear understanding of their respective roles and responsibilities in a temporary organizational environment. This requires **Human Resources Management**. Often these temporary organizational arrangements take place within a traditional management organizational setting, which introduces the concept of a **Matrix Organization**.

Projects are only launched for purposes of achieving change through predetermined objectives, or at least they should be! Because of the relative uniqueness of every project and the rapidly changing conditions as depicted by the time-effort curve described above, the final outcome of every project is always uncertain.

This gives rise to the need for special and constant attention to the forecast final results in terms of meeting the ultimate objectives, including all resources consumed. Based on this forecast, especially if the forecast is unfavorable, it is possible to modify direction by exercising **Control**.

Control is only achieved if all parties to the project clearly understand their respective roles and

responsibilities as a result of careful planning and communication. Moreover, the status of the project at any given time is only apparent through consistent and accurate **Feedback**. Often this feedback can only be fully understood through a proper interpretation of the **Project Environment**, both internal and external. Responses to the project environment are usually referred to as Public Relations.

Collectively, these activities come under the heading of **Communications Management**.

People and communication alone are not enough to implement a project. It is the service that people offer that is needed to execute the project. It is a common experience that a major portion of a project manager's time must be given over to procuring peoples' commitment to the objectives of the project. In addition, materials and equipment are also typically required. The commitment of these goods and services are obtained through **Contract/Procurement Management**.

Uncertainty was mentioned earlier. Uncertainty is associated with probability and risk. Prudent management will take steps to mitigate the possibility of a less-than-favorable outcome by reducing the project risk wherever this can be achieved cost effectively. This leads to the need for a comprehensive understanding of the nature of the project in the first place, especially if it is a complex and interdisciplinary project. These activities are identified as **Risk Management**.

Finally, to tie all these PM Functions together, the PMBoK Standards Committee concluded that a further PMBoK section would be required to provide a frame of reference or overview. This section, which is not strictly a project management function, has been given the name **Project Management Framework**. From an educational standpoint, however, it is another subject area in its own right.

The Project Management Framework provides the opportunity in which the concept of a matrix can be developed to demonstrate the interdependencies and interfaces between the respective functions. It also provides the opportunity to take an overview perspective of a number of other aspects of project management. Examples include the process of control, typical project life cycles, the need for project integration and interface management, and the place and impact of project management in the various public and private sectors.

It can also be the repository of some general project management background and information as well perhaps as some of the more universal tools and techniques of project management.

## 5.0 Summary

Managing a project is very different from managing a production facility, or other established on-going operation. Differences are to be found in the project life cycle, substantial changes in the level-of-effort required at different phases of the project and the consequent difficulties of exercising control.

Project management is not difficult to understand. However, depending on the nature and circumstances of the project, success may be difficult to achieve. The key is to be found in establishing the project Executive's philosophy and mandate, understanding the project's external environment, followed by thorough and early planning to provide the basics for sound execution and control.

The goal must be to establish a solid record of successful projects, which have been identified as financially and economic ally sound and to manage them from concept-to-operation, while conserving human and material resources and protecting the physical environment. This can only be achieved by developing a network of creative and experienced project management professionals through an explicit project management education and training program.

Therefore, this presentation includes a brief description of the background, need, structure and content of a unique body of knowledge relating to the management of projects, and on which education and training can be based. It is to be hoped that a convincing case has been made for the establishment of such a program, as the basis for a recognized professional discipline.

Max Wideman

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## Appendix A

### Summary of Major Functional Responsibilities of Project Management

The following brief descriptions describe the major functional responsibilities on a construction project.

#### A1 Strategic Planning

In large complex projects there is a need to do initial project management planning - in short, planning the plan. A logical sequence commences with a global project description and a clear statement of project objectives. Next follows a high level project Work Breakdown structure (WBS) with a corresponding project organization and functional responsibility chart.

Then comes the assignment of responsibilities, the development of a high level schedule network and consequent resource loading. It should then be possible to develop an optimized Master Schedule. The results of this planning effort should be assembled into a document known as the Project Plan. It should be one of the major deliverables of the project's Concept Phase, described in the text. Table A-1 shows the contents of a typical Project Plan.

#### A2 Planning and Scheduling

Scheduling, or time management, is one of the key functions of managing a project. Failure to achieve established milestone dates inevitably affect project costs unfavorably. There are four steps:

1. **Planning:** establishing the required activities, their logical sequence, restraints and interfaces
2. **Scheduling:** adding durations and resources and adjusting for optimum results
3. **Monitoring:** evaluating progress against plan
4. **Control:** exercising positive corrective action over unacceptable variances

#### A3 Budgeting and Estimating

At the earliest possible time, an acceptable project budget breakdown must be established, which properly reflects the best estimate of the work required to achieve the overall project objectives. This will form the basis for regular cost monitoring and reporting.

From time to time, updated cost estimates will be required, as well as detailed estimates of individual work packages. The quality and accuracy of these estimates will improve as the project proceeds and information becomes available in greater detail. In order to obtain "best value for money", major cost components may be subject to comparative "value analysis" where suitable alternative choices exist.

## Table A-1: Typical Project Plan Content

1. Background description of the project's scope
2. Statement of the Scope of Work
3. Technical Standards
  - Environmental - quality & safety
  - Performance criteria - Evaluation studies
  - Design approach - Technical specifications\*\*
  - Location and layout
4. Cost and schedule considerations
5. Procurement and contracting policy
6. Construction approach
7. Operating and maintenance requirements
8. Certification and commissioning requirements
9. Project organization
  - Organization charts
  - Responsibilities and authorities
10. Project Management Guidelines
  - Approach - Accounting/financial
  - Project Procedure Manual - Documentation control
  - Planning & progress monitoring - Administration & personnel
  - Project budget & cost monitoring - Project reporting
  - Engineering & design - Trade union interfaces
  - Procurement & contracts - Publicity
  - Material control - Training
  - Construction - Safety
  - Quality assurance/Quality control - Project auditing
  - Certification
11. Project team facilities
12. Computer support facilities
13. Applicable government and regulatory agency codes
14. Applicable owner standards & procedures

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\*\* The Technical Specification is often enlarged to contain all information either under "Technical Basis" or under parts of other sections.

## **A4 Cost Control and Accounting**

Control of costs is achieved through monitoring, analyzing, reporting and exercising control over commitments and expenditures with due regard to schedule. A key element is maintaining visibility of the Forecast Final Cost of the Project and exercising corrective action in good time, by regular progress assessment and determination of future commitments and expenditures.

Project accounting deals with the control and historic recording of actual cash payments to consultants, contractors, suppliers others for services provided to the project in a manner which enables comparison with the project budget.

Definitive and detailed procedures are essential in this function to ensure the financial integrity of the project.

## **A5 Regular Status Reporting**

Reporting on a regular basis, of timely up-to-date information, is essential to keep the client and others informed of the status of the project and to permit all necessary decisions and actions to be taken promptly. Typical reports include:

- General project status
- Progress compared to schedule
- Cost compared to budget
- Activity status of consultants, contractors and management
- Procurement status
- Permits, agreements and contract negotiations
- Construction status
- Completion certification & commissioning status

## **A6 Management of Design Consultants**

This function ensures that the design work is proceeding in a timely manner and that the output of this work will be within the constraints of the project's scope and budget. It may include:

- Working with the owner to prepare a design brief outlining the project requirements to form the basis of consultant selection, including prequalification based on capability and staffing
- Selection recommendations
- Negotiating fee structures, terms of reference and responsibilities with the respect to the project team
- Award recommendations
- Briefing, expediting and ensuring regulatory and user input coordination

## **A7 Procurement and Contract Administration**

The extent of special expertise and the level of effort required in this function is substantial, as will be

seen from the following sub-sections.

### ***A7.1 Procurement***

Procurement involves the systematic execution of procedures for purchasing all materials, equipment and services needed for the project, in good time, and in a manner which is cost effective. This process includes:

- Establishing procurement criteria and procedures based on good commercial practice and in agreement with the owner
- Interaction with the project scheduling and budgeting activities
- Agreement with the owner regarding signing and requisitioning authorities
- Prequalification of suppliers of goods and services, including sourcing, availability and market conditions
- Establishing suitable standard documents for proposals, tender calls, contract general and special conditions, and purchase orders
- Issue, receipt, assessment and recommendations for award in respect of proposals/bids/quotes
- Establishing a material management and control system, including verification of materials and equipment received
- Administration of contracts

### ***A7.2 Expediting***

Expediting is essential to determine whether schedule objectives will be met, and what corrective action will be necessary to protect against unexpected developments with regard to deliveries. This applies to all materials, equipment and services needed for the project, whether procured externally or provided internally by the owner.

### ***A7.3 Quality Assurance and Control***

Quality itself is the composite of material attributes, including performance features and characteristics, of the product or service required to satisfy the need to meet project objectives.

A quality assurance program, therefore, identifies these objectives and establishes a strategy of client interfacing for organizing and coordinating planned and systematic controls for maintaining established standards right from early design work through to commissioning.

Following identification of specific system requirements, a quality control program is necessary to exercise direct influence on results by the collection of specific technical data for analysis and decision as to acceptance or rejection.

### ***A7.4 Payment Certification***

Payment certification involves verifying interim and final payment entitlement for every consultant, supplier and contractor engaged on the project in accordance with the terms of the respective contracts.

However, in respect of suppliers and contractors, much of this work is delegated to the respective consultants who have a professional responsibility to ensure that the work conforms to their technical requirements. Nevertheless, the volume of paper work is substantial and must be closely integrated with Project Accounting.

## **A8 Management of Construction and Commissioning**

### ***A8.1 Construction Management***

Construction management includes the setting of a strategy, followed by its implementation, for the procurement of constructed work. Therefore, it is important that the project manager ensures that the construction manager oversees the following, to the extent that they are not incorporated into individual contract documents:

- Provides input to the design and reviews contract documents as to constructability and cost
- Provides input to the project schedule with respect to construction activities and logic
- Recommends tendering strategies and procedures for the selection of tenderers, including tenders for pre-purchased equipment
- Has responsibility for calling, receiving, evaluating and comparing tenders, and recommending contract awards
- Mobilizing and managing the construction site, including temporary facilities, site logistics, storage on and off site for pre-purchased materials and equipment, and general site conduct
- Mobilizing contractors, reviewing their schedules, manpower and methodology
- General day-to-day scheduling, coordination and supervision
- Expediting submission and review of shop drawings and samples
- Field contract administration, distribution of field clarifications, special work authorizations, and distribution of any change orders
- Claim avoidance measures
- Harmonious trade contractor and labor relations
- Monitors construction progress and cost
- Calls for inspection and reinspection of defective work
- Certification of contractors' physical progress
- Submission of required as-built drawings, operating manuals and instructions and similar contract completion documentation
- Administers the correction of faults during the warranty period

### ***A8.2 Commissioning***

Typically, commissioning and start-up is carried out by the owner's users or operational staff who will actually run the facility. However, prior to start-up, every system and every part of the project must be brought into operational mode ready for formal handover. The whole project team is therefore required to assist by organizing and managing the transition from construction/installation to operation. A carefully developed set of commissioning procedures is necessary to ensure orderly and successful project completion, including:

- Responsibilities and organization
- Detailed equipment and systems commissioning and start-up sequence, including check-out, static tests, "dry and wet" operational tests, performance tests, etc.
- Client acceptance, including equipment and systems tagging, opportunities for training and general familiarization, designation of temporary working and storage areas for operations staff, etc.
- Deficiency lists, and their progressive correction
- Building occupancy permits
- Ensuring completion of all final contract documentation

### **Work Packages - Essential Rules**

A Work Package is a generic term describing a unit of work at the lowest developed level of the relevant part of the Work Breakdown Structure (WBS). The distinction is made between the lowest developed level and the lowest possible level, because at any given time not all work packages will be classified at the same level. In other words, a work package is **not** a distinct level in the WBS.

To be effective, work packages should be controlled by the following rules.

Rule 1: A work package must represent a unit of work at a level where work is performed.

Rule 2: It must be clearly distinguishable from all other work packages.

Rule 3: It should have scheduled start and completion dates. Rule 4: It should have a budget.

Rule 5: Its size and duration should be limited to relatively short spans of time.

Rule 6: It must integrate with other work packages and schedules.

Rule 7: It must represent a level at which actual costs can be collected or assigned.

Note, however, that a project should not be broken down to too great an extent. If some work packages are too small, unnecessary administrative effort will be expended in maintaining the information flow. This suggests some additional rules governing work packages:

Rule 8: On small projects the following "test of reasonableness" is suggested:

A work package should at least be large enough to constitute a scope of work that could be competitively bid and contracted for by itself.

Rule 9: On large, multi-million dollar projects design work packages should not be less than, say, 300 man-hours and two months in duration. For construction, a minimum work package value of, say, 0.1 percent is a good rule of thumb.

A number of work packages may be assembled into a contract package for procurement purposes. Within such a contract, the identity of the individual work packages should be maintained for control purposes. However, to be consistent with the Work Package definition, the following further rule must be applied:

Rule 10: The same work package must not appear in more than one contract. If this is likely to happen, the affected work package should be subdivided, and the respective parts separately defined and coded.

## Glossary of Project Management Terms

### Management Definitions

**Project Management Institute :** A non-profit organization dedicated to advancing the state-of-the-art in the profession of project management located in Pennsylvania, USA.

**Project Management:** the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participant satisfaction.

**Project Management Body of Knowledge (PMBok):** all those topics, subject areas and intellectual processes which are involved in the application of sound management principles to the collective execution of any types of effort which qualify as projects.

**Project Management Framework:** The idea of setting out to achieve certain predetermined objectives in several concurrent areas pre supposes the application of discipline and control through sound management practices. This in turn requires delegation of effort to various specialized "functional" management areas in which the separate objectives are to be achieved.

**Scope Management:** the function of controlling a project in terms of its goals and objectives through the processes of conceptual development, full definition or scope statement, execution and termination.

**Quality Management:** Quality itself is the composite of material attributes (including performance features and characteristics) of the product or service which are required to satisfy the need for which the project is launched. Quality standards may be attained through the sub-functions of Quality Assurance and Quality Control.

**Quality Assurance (Management):** the development of a broad program which includes the processes of identifying objectives and strategies, of client interfacing, and of organizing and coordinating planned and systematic controls for maintaining established standards. This in turn involves measuring and evaluating performance to these standards, reporting results and taking appropriate action to deal with deviations.

**Quality Control (Technical):** the planned process of identifying project established system requirements and exercising influence through the collection of specific (usually highly technical and itself standardized) data. The basis for decision on any necessary corrective action is provided by analyzing the data and reporting it comparatively to system standards.

**Time Management:** the function required to maintain appropriate allocation of time to the overall conduct of the project through the successive stages of its natural life-cycle, (i.e. concept, development, execution, and finishing) by means of the processes of time planning, time estimating, time scheduling, and schedule control.



**Cost Management:** the function required to maintain effective financial control of the project through the processes of evaluating, estimating, budgeting, monitoring, analyzing, forecasting, and reporting the cost information.

**Human Resources Management:** the function of directing and coordinating human resources throughout the life of the project by applying the art and science of behavioral and administrative knowledge to achieve the predetermined project objectives of scope, cost, time, quality and participant satisfaction.

**Communications Management:** the proper organization and control of information transmitted by whatever means to satisfy the needs of the project. It includes the processes of transmitting, filtering, receiving and interpreting or understanding information using appropriate skills according to the application in the project environment.

**Contract-Procurement Management:** the function through which resources (including people, plant, equipment and materials) are acquired for the project (usually through some form of formal contract) in order to produce the end product. It includes the processes of establishing strategy, instituting information systems, identifying sources, selection, conducting proposal or tender invitation and award, and administering the resulting contract.

**Risk Management:** the art and science of identifying, analyzing and responding to risk factors throughout the life of a project and in the best interests of its objectives.

### **Other Useful Definitions**

**Control:** The exercise of corrective action as necessary to yield a required outcome consequent upon monitoring performance.

**Control Functions:** Scope, Quality, Time and Cost are the basic or core functions of project management.

**Effort:** The application of human energy to accomplish an objective.

**Environment (Project Environment):** The combined internal and external forces, both individual and collective which assist or restrict the attainment of the project objectives. These could be business or project related or may be due to political, economic, technological, environmental or regulatory conditions.

**Feedback:** Information (data) extracted from a process or situation and used in controlling (directly) or in planning or modifying immediate or future inputs (actions or decisions) into the process or situation.

**Integrative Functions:** Risk, Human Resources, Contract/Procurement and Communications are the essential "people oriented" functions of project management.

**Matrix Organization:** A two dimensional organizational structure in which the horizontal and vertical intersections represent different staffing positions with responsibility divided between the horizontal and vertical authorities.

**Project:** Any undertaking with a defined starting point and defined objectives by which completion is identified. In practice, most projects depend on finite or limited resources by which the objectives are to be accomplished.

**Project Life Cycle:** The four sequential phases in time through which any project passes, namely: Concept; Development; Execution (implementation or operation); and Finishing (termination or close out). Note that these phases may be further broken down into stages depending on the area of project application.

**Project Manager:** The individual appointed with responsibility for project management of the project.

**Project Phase:** The division of a project time frame (or project life cycle) into the largest logical collection of related activities.

**Project Stage:** A sub-set of Project Phase.

**Project Team:** The central management group headed by a project manager and responsible for the management and successful outcome of the project.

**Scope:** The bounded set of verifiable end products, or outputs, which the project team undertakes to provide to the project sponsor. The required set of end results or products with specified physical or functional characteristics. A statement of scope should be introduced by a brief background to the project, or component, and the general objective(s).

**Work Breakdown Structure:** A task-oriented "family tree" of activities which organizes, defines and graphically displays the total work to be accomplished in order to achieve the final objectives of the project.