CHAPTER 2 : PROJECT MANAGEMENT

1 WHAT ARE PROJECTS ?

1.1 The simplest definition of a project is "*something which has a beginning and an end*".

1.2 Projects come in many guises. There are traditional major projects from heavy engineering industries such as shipbuilding, aerospace, construction and energy. There are significant endeavors involving large, dedicated teams and often requiring the collaboration of several sponsoring organisations.

1.3 On the other hand, the projects which most of us are involved are smaller. Typically, projects at work are smaller : engineering or construction projects to build new facilities : maintenance of existing facilities ; implementation of new technologies or computer systems; research, development and product launches; or management development or training programs. Social environment projects include : moving house : organising an event in the community; or going on holidays.

1.4 The purpose of a projects may be :-

1.4.1 a business purpose, for example to increase profitability, efficiency, turnover or employment

1.4.2 a social purpose, for example to achieve relaxation or enjoyment, or to raise funds for a worthy cause

1.4.3 a humanitarian purpose, for example to provide disaster relief

1.5 To be complete, the definition of a project should therefore reflect the successful achievement of the purpose i.e. *"an endeavour in which human, material and financial resources are organised in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives"*.

1.6 Hence, the essential features of a project are that it is a unique piece of work, undertaken using a novel organisation to deliver beneficial change. These features imply that projects carry considerable uncertainty and risk, that a key role for project managers is integration of the novel organisation and that they a finite in duration.

2 WHAT IS PROJECT MANAGEMENT ?

2.1 There are two views in defining project management :

2.1.1 the traditional view defines project management in terms of a body of knowledge of tools and techniques.

2.1.2 the alternative view defines project management in terms of the management processes required to undertake a project as defined above.

2.2 Project management, as a modern management discipline, is about 40 years old. Its beginnings are sometimes measured from the Atlas Project in the United States, starting in 1953. In those 40 years, a considerable *body of knowledge* has built up of effective tools and techniques. However, there is little formal guidance of how and when to apply them.

2.3 There exists within the body of knowledge two methodologies, the *critical path method* (CPM) and the *cost specification* (C/SPEC).

2.3.1 CPM was developed independently in the chemical, shipbuilding and power generation industries in the 1950s. It focuses on a single objective, managing time, using critical path networks. The CPM methodologies sometimes called CPA (critical path analysis) or PERT (programme evaluation and review technique), although strictly the latter should only apply when network is also used to track progress.

2.3.2 C/SPEC (or cost/schedule control system criteria (C/SCSC)) was developed by the US defence industry. It focuses on three objectives : managing scope, organisation and cost. Scope is managed through a structured definition of the work called *a work breakdown structure* (WBS) and organisation through an *organisation breakdown structure* (OBS). Cost is managed through a *cost breakdown structure* (CBS).

2.4 This traditional view produces an undue focus on work, and completing it within time, cost and quality.

2.5 The alternative view defines project management the process by which a project defined above, is completed successfully, that it achieves its business purpose. There are three dimensions to this process :

2.5.1 the project objectives

2.5.2 the management processes to achieve the objectives

2.5.3 the levels at which the processes are applied

2.6 The definition of a project implies that the delivery of the project's purpose requires the management of five project objectives :

2.6.1 managing scope

2.6.2 managing organisation

2.6.3 managing quality

2.6.4 managing cost

2.6.5 managing time

2.7 The traditional approach focuses on the last three objectives of managing quality, cost and time. The management of projects is a compromise by which quality, cost and time are traded against each other to achieve the optimum outcome.

3 ENGINEERING CONSTRUCTION PROJECTS

Engineering construction is the construction of process or power generation plants.

3.1 Planning the construction stage

3.2 Initial overall planning is done during tender preparation before contract award. A preliminary schedule is included in the estimate. On contract award a detailed schedule is produced, linking engineering, procurement and construction stages. This is issued as the master schedule, and is the baseline for more detailed schedules. From this document, the planner develops the construction schedule in sufficient detail to set milestones for individual subcontracts.

3.3 On fully subcontracted projects, it is only necessary to highlight important milestones and interfaces with other subcontracts. The construction plan is linked to the overall project schedule, so the effects of any movement in front-end activities on the completion date can be seen, and timely corrective action taken. This linking also allows changes in construction activities to be fed

back into the schedule to reflect different engineering and procurement requirements.

3.4 Organising construction personnel

3.5 Having established the construction schedule, the manager then establishes the construction site. One of the key issues is mobilisation of the staff in accordance with the schedule. It is important that personnel are mobilised in time to allow them to become familiar with the project. To have a successful project, all personnel should clearly understand their responsibilities, and work together as a team.

3.6 The present trend is to keep the number of site staff to a minimum, with people carrying out multiple duties. It is then even more important that all personnel understand their responsibilities if duplication of effort or omissions are to be avoided. This is achieved by providing all personnel with clear job descriptions as they arrive on site, and by holding regular team meetings.

3.7 Implementing the construction stage

3.8 The construction stage consists of the following activities :-

3.8.1 site establishment

3.8.2 producing specific site procedures

3.8.3 prequalifying subcontractors

3.8.4 compiling tender documents

3.8.5 issuing tenders

3.8.6 reviewing tender submissions and selecting subcontractors

3.8.7 commencing work in accordance with the construction schedule

3.8.8 controlling site activities

3.8.9 handing over and closing-out project

3.9 Usually a small team is established in head office to handle site preparation, including producing site procedures, developing requirements for temporary facilities, prequalifying subcontractors and awarding initial contracts. They also liaise with other departments to review the design and advise on construction requirements.

3.10 Weekly meetings are held on site with subcontractors to coordinate activities and address problems, both engineering and commercial.

3.11 Construction control systems

3.12 It is important to implement systems to maintain control of site activities. Traditionally these were manual systems, but gradually they are becoming more computerised, using information transferred from the engineering and procurement databases. As a minimum, systems are required to control the following activities :-

3.12.1 material receipt and issue

3.12.2 engineering documentation

3.12.3 subcontracts

3.12.4 planning

3.12.5 progress

3.12.6 quality

3.12.7 handover to client

3.13 When developing systems, it is important to define exactly what is required, and to match requirements as closely as possible.

3.14 Development and Organisation of Projects

3.15 From concept to implementation, the stages in the development of construction projects fall into broadly consistent patterns, but in timing and degree of emphasis each project takes on its own unique character.

3.16 The Life Cycle of a Construction Project

3.17 Six basic phases contribute to developing a project from an idea to reality :-

3.17.1 Concept an feasibility studies

3.17.2 Engineering and design

3.17.3 Procurement

3.17.4 Construction

3.17.5 Start-up and implementation

3.17.6 Operation or utilisation

3.18 The degree of overlap among phases, in both time and operations performed, varies widely from one project to another, as does the distribution of responsibilities.

3.19 Concept And Feasibility Studies

3.19.1 Most construction projects begin with recognition of a need for a new facility. Long before designers start preparing drawings, and certainly well before field construction can commence, considerable thought must go into broad-scale planning.

3.19.2 Elements of this phase include conceptual analyses, technical and economic feasibility studies, and environmental impact reports. Traditionally, these early stages are handled by the owner alone, or by

the owner working with consultants knowledgeable of the most important factors affecting the situation.

3.19.3 Considerable amounts of free information are available from, or offered by, public and private organisations that may benefit from, or be adversely impacted by, a new facility.

3.20 Engineering And Design

3.20.1 Engineering and design have two main phases : (1) preliminary engineering and design : and (2) detailed engineering and design. These phases are traditionally the domain of architects and design-oriented engineers.

3.20.2 Increasingly, however, the owner's operations and utilisation knowledge and the field constructor's experience are being more strongly injected at this stage through direct participation and stringent review procedures.

3.20.3 *Preliminary Engineering and Design* stress architectural concepts, evaluation of technological process alternatives, size and capacity decisions, and comparative economic studies. To great extent, these steps evolve directly from the concept and feasibility stage. In industrial construction, it involve input and output capacity decisions, choices between basic process alternatives, general site layout, and often the preparation of overall process flowsheets. Once preliminary engineering and design are essentially complete, there is generally and extensive review process before detailed work is allowed to proceed.

3.20.4 *Detailed Engineering and Design* involve the process of successively breaking down, analysing, and designing the structure and its elements so that it complies with recognised standards of safety and performance while rendering the design in the form of a set of explicit drawings and specifications that will tell the constructors exactly how to build the structure in the field.

3.21 Procurement

3.21.1 Procurement involves two types of activities, contracting and subcontracting for services of general and specialty construction contractors, and obtaining materials and equipment required to construct the project.

3.21.2 The traditional form for procuring construction services as well as most of the materials and equipment required for a project is to solicit competitive bids for a single general contract. This takes place soon after the detailed engineering and design phase has produced a comprehensive set of plans and specifications. The general contractor then handles all subcontracting, plus the procurement of materials and equipment.

3.22 Construction

3.22.1 Construction is the process whereby designer's plans and specifications are converted into physical structures and facilities. It involves the organisation and coordination of all the resources for the project - labour, construction equipment, permanent and temporary materials, supplies and utilities, money, technology and methods, and time - to

complete the project on schedule, within budget, and according to the standards of quality and performance specified by the designer.

3.22.2 The key roles at this stage are played by the contractors and subcontractors and their employees from the building trades. There is also considerable input for inspection and interpretation from the architect/engineer. Supporting roles are played by suppliers of materials and equipment, specialty consultants, shipping and transport organisations, etc.

3.23 Start-Up And Implementation

3.23.1 Most structures and facilities of any significance involve a start-up and implementation phase. In both simple and complex cases, much testing of components is done while the project is underway. Nevertheless, as the project nears completion, it is important to be sure that all components function well together as a total system.

3.23.2 This mainly involves testing, adjusting, and correcting the major electrical and mechanical systems so that they perform at their optimum level. Often this phase also involves a warranty period during which the designer and the contractors can be called back to correct problems that were not immediately evident upon initial testing and to make adjustments to better suit the facility to the owner's needs after he has had a chance to try it out.

3.23.3 In many projects, especially large industrial facilities such as power plants, refineries, and factories, start-up is a highly complex process that pushes the facility to its technological limits, as well as seeing that

it operates efficiently under normal conditions. In this case, it requires months of careful advance planning and once underway, demands good coordination and supervision.

3.24 **Operation And Utilisation**

3.24.1 The functional value of the project will depend upon the decisions and implementation of the objectives developed during the preceding phases. With a projected operational life of 20 to 25 years or more, it is evident that the overall cost and value to the owner throughout the operating life are determined largely during the period from conception through start-up.

3.24.2 In the case of major alterations or expansions, the operations phase can also involve recycling through the first five phases of a project mentioned above, whether the work is done in-house or by contract.

4 BASIC MANAGEMENT ACTIVITIES

4.1 Management theory identifies four essential management activities that must be accomplished in any successful organisation. Organisations can be designed to best perform these according to the needs of a specific projects :-

4.1.1 Scoping - Clearly define desired project objectives

4.1.2 Planning - Predetermine a course of action to achieve project objectives

4.1.3 Organising - Integrate individual, consultant and contractor efforts into an effective team

4.1.4 Controlling - Monitor, influence and direct achievement of project objectives throughout the performance phase

4.2 *Scoping* involves establishing realistic and specific objectives which establish in advance the desired results. Objectives must be stated in definite and measurable terms which cover costs, schedules and quality or performance requirements. Full and unequivocal communication of project objectives to project team members is essential if maximum performance is to be achieved. Objectives must be reasonable and achievable. Project team members will quickly become skeptical of unworkable or overly optimistic objectives.

4.3 *Planning* activities include programming, costing and scheduling. These activities are highly interrelated and are developed in overlapping phases rather than sequentially. Planning for most projects will evolve from a high-level plan in the early stages to a very detailed implementation plan during performance phase. An integrated plan will involve a work breakdown structure of codes for estimating, scheduling and costing direct and indirect work activities.

4.4 *Organising* is the process used by managers to relate tasks to people, other firms, regulatory agencies and other interested groups in order to achieve and economical and timely performance. In developing an efficient organisation, the manager must deal with the design of the structure, delegation of responsibility, working relationships between individuals and groups and creation of a communications program designed to keep everyone fully informed. In general, the number of managerial levels should be kept to a minimum, thus reducing management interfaces, but not too flat as it may exceed the manager's effective span of control. The optimum number of persons reporting to a single manager will vary considerably depending upon

the manager's effectiveness, employee skill and temperament, as well as the nature of the work.

4.5 *Controlling* requires an awareness of the current status of cost, schedule and quality performance compared to project goals. Control can be achieved through frequent personal inspection of the operation, normally called supervision, by a knowledgeable person in order to judge whether or not the work is being properly performed. As the manager's organisational span increases it is apparent that all of the work can no longer be supervised. The manager must therefore utilise a systematic process to identify deviations from the plan at an early stage when remedial action is still possible. Control systems can keep the manager informed of the variations from the plan and effective remedial action is necessary if control is to be achieved.

5 ORGANISATIONAL CONCEPTS

5.1 There are several possible organisational approaches to the design and construction of a project. The major concepts addressed here include (1) functional, (2) task force, (3) line and staff, and (4) matrix.

5.2 *Functional* approaches have traditionally been used in the construction industry. The strengths of these approaches will include high stability, high professional standards, incorporation of the latest technology and an excellent corporate memory. In a functional organisation, everybody knows where they stand compared to others, understands their tasks and has a permanent home base. Weaknesses of functional organisations can include low adaptability, minimum appreciation of overall project objectives, overly rigid operating rules, resistance to change and difficulty in developing well-rounded project

managers. An overall functional organisation can be helpful when the owner acts as project manager with a minimum staff, depending upon others for the functional expertise. Functional organisations work best when overall managers are skillful, people-oriented and can help avoid internal conflict with other functional groups. The functional organisation permits the tightest discipline control of any organisational concept.

5.3 The *task force* has been notably successful when a self-sufficient organisation is required. The strengths of the task force include high adaptability and high understanding of the overall task and can foster an excellent team spirit if given the proper leadership. The task force features close personal relationships and can be responsive to ideas and methods. The weaknesses of a task force feature poor stability. Everyone may not have a corporate home for long term career development and for continuity of employment between assignment periods. The task force by itself has no corporate memory , the memory being that of the individuals assigned to the projects. Everyone may not understand his or her own task, and there are no functional checks and balances to preserve workmanship quality and accepted standards. Task forces work best when all team members can be located physically in the same area to foster closer personal relationships, when attempting something new without recognised standards and when the team is made up of very experienced members.

5.4 The *line-and-staff* organisation has worked well in the manufacturing industries. Many construction companies evolved from a functional organisation to a line-and-staff organisation as growth required additional

management strengths. Strengths of the line-and-staff organisation include the combination of functional strengths and expertise with the project-oriented team. The form of organisation strikes a balance between overall control of both craftsmanship and project objectives. Weaknesses are sometimes evident in the conflict between the operating organisation and the functional staff. Organisation structure s tend to be somewhat top heavy, and overall costs may exceed more simplified operating concepts.

5.5 The *matrix* organisation is something of a cross between a task force and a functional organisation and represents an attempt to preserve the strong points of each. The matrix organisation endeavors to solve the conflicts between the operating line organisation as represented by the project manager and the functional staff by opening up lines of communications at all levels and through assigning subordinate managers dual reporting responsibility. Project responsibilities such as scope, cost, and schedules are the responsibility of the project manager. Functional responsibilities such as quality assurance, design standards and internal company policies are the responsibility of the functional staff. The matrix organisation combines functional strengths with the advantages of a project-oriented team. It fosters and excellent climate for developing project managers, retains access to the corporate memory and allows control of both craftsmanship and project objectives. Disadvantages include difficulties in precisely defining accountability to both functional and project managers. The matrix organisation is appropriate when both project accountability and functional expertise are required.

6 CONTRACTUAL RELATIONSHIPS

6.1 There are numerous alternative contractual approaches to bringing together a team for the design and construction of a project. The principal categories to be addressed include the traditional approach, the owner-builder, turnkey (design-construct or design-manage), professional construction management and program management. Each has its advantages and disadvantages for a particular application, and each has developed a certain degree of flexibility so that in reality many of the individual alternatives overlap one another.

6.2 In the *Traditional Approach*, the owner employs a designer (architect, architect/engineer or engineer) who first prepares the plans and specifications, then exercises some degree of inspection, monitoring or control during construction. Construction itself is the responsibility of a single general contractor under contract to the owner. The traditional approach can be implemented using the single-fixed-price or lump-sum contract, a unit-price contract, a negotiated cost-plus-fixed-fee contract or a guaranteed maximum-price arrangement. Other variations or combinations are also utilised.

6.3 The *Owner-Builder* approach is often referred to as "force account". The owner performs both their own design work and some or all of the actual construction with their own forces. This method of performing design and construction can be best justified when the volume of work is relatively large and relatively constant over a long period of time, and where project management can be separated form operational management.

6.4 *In Design-Construct or Design-Manage* (Turnkey) method, all phases of a project, from concept through design and construction , are handled by the

same organisation. In the case of design-construct, the constructor acts as a general contractor with single-firm control of all subcontractors. In the case of design-manage, construction is performed by a number of independent contractors. Using either method, construction can readily be performed under a phased construction program to minimise project duration. The typical design-construct organisation was previously organised along functional lines. Design, procurement and construction departments were coordinated by a project engineer who was responsible for the overall project. The real responsibility initially rested with the design group and shifted to the construction group as the design neared completion. As projects become more complicated and early completion became increasingly important, clients began to demand that one person be placed in charge. The project manager was created, as the leader of a task force type of organisation in order to be more responsive to owner requirements. The project manager is placed in full charge of engineering, procurement, construction and support personnel. The task force operated as a separate organisational unit made up of functional personnel loaned from their respective departments on a full-time basis for the duration of the project assignment. As the task forces became increasingly self-sufficient, relationships with the functional departments became more and more remote, and project managers were more concern with project performance and short-range economy than with enhancing the parent organisation's long range knowledge base, leading to deterioration in engineering and performance quality and in the ability to plan and estimate new projects. A new concept of matrix organisation was designed to preserve

the advantages of the project manager led task force while regaining the optimisation of the discipline excellence of the initial functional organisation. Sometimes called a task force within a matrix organisation, features a dual reporting role for key members of the project team. The turnkey approach can be utilised under just about any form of contract.

6.5 *Professional Construction Management* treats the project planning, design and construction phases as integrated tasks. This approach unites a three-party team consisting of owner, designer and construction manager in a non-adversary relationship and it provides the owner with an opportunity to participate fully in the construction process. The team works together from the beginning of design to project completion, with the common objective of best serving the owner's interest.

6.6 *Program Management* (project management) is an emerging concept being used on some of the very largest projects. Program management services may include no design or direct construction but the program manager could handle overall management of a number of individual projects related to an overall program. The program manager serves as the single point of contact to the owner to coordinate and manage the various other parties involved in planning, design, procurement and construction. Program management can be organised using functional, task force, and matrix organisations.

PLANNING AND CONTROL OF OPERATIONS AND RESOURCES

7.1 Planning, scheduling and control of the functions, operations and resources of a project are among the most challenging tasks faced by a construction manager. Normally, this responsibility involves coordinating design with

construction to produce the necessary plans and specifications, which provides the overall planning, scheduling and control needed to sequence operations properly and to allocate efficiently the resources involved.

7.2 There are many different analytical tools and graphical techniques for planning, scheduling and control of operations and resources. Network-based critical path method (Program Evaluation and Review Technique (PERT) and CPM) are among the most powerful tools available. However, there are a few other alternatives which include bar charts, progress curves, matrix schedules and linear balance charts.

7.3 A *bar chart* graphically describes a project consisting of a well-defined collection of tasks or activities, the completion of which marks its end. It is generally organised with all activities listed in a column and a bar representing the progress of each activity is drawn between its corresponding scheduled start and finish times along the horizontal time scale. Advantages of bar charts include easy general comprehension due to its simple graphical form, common acceptance and wide spread use in industry, and fairly broad planning and scheduling tool which requires less revision and updating.

7.4 *Progress Curves*, also called S curves, graphically plot some measure of cumulative progress on the vertical axis against time on the horizontal axis. Progress can be measured in terms of money expended, quantity surveys of work in place, man-hours expended, or any other measure which make sense. Planned and actual progress curves can be superimposed on a bar chart to make a useful hybrid report.

7.5 *Matrix schedules* are a tool that has evolved and become fairly common on high-rise buildings with successive floors repeating essentially the same plan. The technique is fairly narrow in its application but it does serve to be effective for documenting and communicating a plan.

7.6 *Linear balance charts* , called the Vertical Production Method (VPM) apply best to linear and repetitive operations. The vertical axis typically plot cumulative progress or percentage completed for different systems of a project, and the horizontal axis plots time.

7.7 The *critical path method* (CPM) is a graphical network-based scheduling technique initiated with the objective to explore the use of computer-aided systems in planning, scheduling, monitoring and controlling. CPM enables planners and managers to thoroughly analyse the timing and sequential logic of all operations required to complete a project before committing time, money, equipment, labour and materials for engineering and construction. Advantages include its ability to concisely represent large numbers of activities, shows the logical interrelationships and dependencies among activities (impact of delay in an activity, change in activity's scope or addition of deletion of activities) and generally useful for forecasting and control.

8 CONCLUSION

8.1 There are three areas to be addressed to make construction a success :-

8.2 **Good Planning**

All site activities should be planned, which includes the direct construction activities and other work such as establishment of temporary facilities.

recruitment and release of personnel and mobilisation of vendor representatives.

8.3 **Good Communication**

Having established a good plan, it is important that it is communicated to all parties, including people in the construction group, the client, the head office engineering and procurement staff, the subcontractors and the site suppliers. Most problems occurring on site are caused by poor communication, especially of revised plans.

8.4 **Good Teamwork**

It is necessary to establish good teamwork on construction projects. This should extend from client to the workforce. Project schedules are now too tight to be successfully completed under the adversarial conditions that existed some years ago. This requires a change in culture, with projects being set up using task forces, and with client and main contractor personnel working together in one office. This builds an atmosphere of trust which assists in resolving problems at a later stage. Relations between main contractor and subcontractors are usually dictated by contractual terms and conditions, but it is being realised that these must allow a team approach to develop if the projects are to be successful.