



# PROJECT CONTROL FOR ENGINEERING

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# **Project Control for Engineering**

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## INTRODUCTION

One of the most important challenges facing engineering and construction management today is the prevention of cost and schedule overruns of the type that have plagued major projects so often in the past. The multiple parties involved in a project (owner, engineer, construction manager, contractors, and subcontractors), the complexities inherent in a project, the pressure of time, increasing regulatory requirements, inflating costs of material and labor, and the uncertainties of nature combine to make major engineered construction a management nightmare. Obviously a project must have a formal project control system if there is to be success, and that system must encompass the engineering effort.

Project control is concerned with resource quantities, time, and costs. Planning and controlling of resources is generally accomplished within the cost control system. All resources, whether they be personnel, material, equipment, supplies, or services, are quantifiable and can be converted to a dollar amount. During the planning of a project, quantity and dollar budgets for these are established. During the controlling operation, actual quantity and dollar performance and rates of utilization are compared with planned performance.

Time and work progress are managed through the schedule. During the planning operation, engineering work tasks are scheduled to fit project requirements and a system for measuring progress of each task is established. During the controlling operation, status is reported against that system.

The benefits of an effective project control system are many. It documents the project plan and actual performance. It identifies problem areas and unfavorable trends. It is a communication tool. It allows project managers and other project participants to “keep a handle” on the work. It feeds into the historical database so that future planning of comparable work can be more accurate. Overall, the project control system is a major factor in the success of the project at hand and the planning of future projects.

Control of engineering activity is generally more difficult than control of construction activity because engineering tasks are more difficult to quantify and track between start and completion, tasks are more parallel and overlapping, and the responsibility for a given design often is shared among various disciplines. The challenge is particularly great on those projects in which engineering overlaps procurement and construction. Engineering work, however, can be controlled. Succeeding chapters of this publication provide details of a system for this control.

## ORGANIZATIONS FOR ENGINEERING

### General

A properly structured organization is key to effective management and control of any project. The planning and controlling of the engineering for a project, where multiple functional departments and many individuals are involved, is particularly complex. It is essential that the work included within the project be fully scoped and defined, and that responsibility be assigned for its accomplishment. Three types of organizational structures may be utilized for managing this work - a functional organization, a task force organization, or a matrix organization.

### Functional Organization

A functional organization is the traditional pyramidal organization wherein each functional department (e.g., Engineering, Accounting, Construction) is organizationally independent of the others and handles all work within its area of expertise. Coordination between departments is handled on an informal basis and resolution of conflicts falls to the senior managers to whom the various departments ultimately report. This type of organization works well when a minimal amount of contact is needed between departments. Within a functional organization, project management becomes an additional duty of senior company managers. It is a feasible, though not particularly efficient, organizational arrangement for management of small projects; it is not effective for large projects.

### Task Force Organization

A task force is an organization comprised of individuals assigned from the functional departments to the task force for the purpose of managing a project. Individuals assigned to the task force are committed full time to the project during the period of their assignment. A project manager is appointed and the other personnel are organized functionally under the project manager. The organization and personnel of the task force may change as the project moves through various phases. The major advantages of a task force are that it permits concentration of resources on a project and involves minimum management levels. This type of organization is particularly suited for large projects.

## Matrix Organization

The matrix organization is a combination of a task force organization and a functional organization. In a matrix, there are two chains of command for each staff member, one along functional lines and the other along project lines. This is achieved by having the staff report to two managers simultaneously - a project manager for project direction and a functional manager for technical direction. The *project* team within the matrix is a group whose members are drawn from various functional departments of the organization and who are committed to support the project or task at hand. Project (team) managers are normally drawn from a pool of such managers. In some situations, both project managers and team members may simultaneously serve on more than one project team.

There are strong and weak matrix organizations. A strong matrix is one where the project team structure is preeminent - i.e., the project manager's authority over the individuals on the project team exceeds that of the functional managers. In a weak matrix, the reverse is true.

Matrix organizations are the most common and also the most complex form of organization utilized for management of engineering work. When well managed, they provide for maximum coordination, information exchange, and resource sharing. Matrix organizations are also the most economical form for management of multiple projects, none of which is large enough to warrant a full task force. The strong matrix is the preferred form<sup>2</sup>.

## The Status of Project Controls in the Organization

Project control, to be effective, must begin during the planning and budgeting of the work. It will continue during the conceptual and detailed engineering phases. If these phases are a part of a contract where engineering, procurement, and construction overlap, engineering project control will be integrated with procurement and construction project control.

The project control function is the "eyes and ears" of management at all levels and the source of project status information for the client. It is also an information center for every professional on the staff. Accordingly, it should be organizationally placed so that it responds directly to the project manager. It **must not** be treated as another accounting function, nor should its activity be decentralized among the functional groups. And it must be recognized as an integral part of management, not as a police force! Management must assess the information provided, then take the necessary steps to implement the action needed.

## PROJECT CONTROL BASICS FOR ENGINEERING

### Types of Engineering Contracts

In industrial construction it is common for engineering, procurement, and construction to be handled in parallel and with some overlap - these are called *Engineering-Procurement-Construction (E-P-C) projects* for purposes of this publication. The engineering portion of the project may be part of a turnkey arrangement administered within a single agency or it may be handled as a separate contract that must tie-in with the contracts of others.

It is possible, however, for engineering to precede completely both procurement and construction. An engineering contract in this case is referred to in this publication as *Engineering-Only (E-O)*. The E-P-C format is the more challenging of the two from a project controls viewpoint.

### The Nature of Engineering Work

The primary products of engineering work are documents to guide both the construction of a facility and the manufacture of engineered equipment for installation in such a facility. Other products are studies, procedure and operating manuals, and various consulting services.

In performing its work, the engineering group is generally organized around engineering disciplines (civil, architectural, structural, mechanical, electrical, etc.) or specialty services (model shop, procurement, environmental studies, economic studies, etc.). These production units of the organization have products such as drawings, specifications, models, manuals, studies, and procurements. Supporting them are such functions as word processing, computer services, accounting, personnel, and others.

Some owners maintain internal organizations for accomplishment of conceptual and/or detail engineering of their facilities. But much if not most of it is handled under contract with an engineering firm. Many contracts in the latter case are reimbursable, although fixed-price contracts are becoming more common, and there are reimbursable contracts with ceilings, targets, or incentives. The typical reimbursable contract is handled in this fashion:

- Professionals within the production units are identified as reimbursable. The client agrees to pay for each hour of work of those reimbursable individuals in an amount equal to the base hourly pay of each individual times a multiplier. This multiplier is in the range of 1.5-2.5.

- Other items are identified as “reimbursable directs.” These are items such as travel, reproduction, computer services, and communications. In most cases, their costs are passed through to the client without markup.
- Items such as general management, accounting, personnel services, and secretarial services are “non-reimbursable directs and indirects,” and are not charged directly to the client. These costs are accounted for within the multiplier noted above. That multiplier also accounts for profit (unless the project is cost-plus) and for personnel fringe benefit costs (burden) such as vacation, medical, FICA, and retirement.

If the contract form is fixed-price or other than the reimbursable described above, the engineering agency still must account fully for the direct costs, project level indirects, general overhead, and any contingency and profit in the pricing.

## Planning and Budgeting

As noted previously, there are activities of direct work in an engineering contract and each has a cost. Other activities that are support in nature, both direct and indirect, are only cost items. Contract progress is tracked against the work activities; costs are tracked against all activities and other cost items. Thus, the project control system must be designed to control both work and cost.

When planning any project, it is desirable to divide the project into well-defined, manageable parts for purposes of control. By controlling the individual parts, it is possible to establish control of the total project. Figure 1 is a matrix representation of the budget that might be established for a typical engineering project. Certain items on this budget include allocations of work-hours as well as costs. Others are budgeted only for cost. Experienced engineering organizations are able to estimate quite accurately the number of engineering documents and the work-hours required. They are also able to estimate the quantity and work-hour requirements for their other products and the costs of other reimbursables and non-reimbursables and, having done this, to establish a multiplier. These estimates become the basis for project control.

Control of work is best based on control of budgeted work-hours for individual work activities (see discussion in following paragraphs for examples). As part of this control, there must be some method for evaluating percent complete of each activity. The methods are established during the planning operation. Methods available are summarized in Appendix A.