SOME CRITICAL ELEMENTS OF ENGINEERING PROJECT MANAGEMENT

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ABSTRACT

A systematic and scientific approach to engineering project management is essential to ensure that the project objectives are fulfilled within the constraints of time, captial. and other resources. This paper examines some critical elements of engineering project management , such as the Work Breakdown Structure (WBS), Gantt chart PERT/CPM, COST estimates and budgets, and project implementation and control. Effective use of these techeniques, in an integrated systems approach to project management, will contributesignificantly towards reducing cost and time over -runs in modern engineering projects.

INTRODUCTION

With the advent of rapid industrialisation, and growth of several hi-tech,captial-intensive industries, a systematic and scientific apprach is essential for managing engineering projects. The ultimate goal of project management is to ensure that the project objectives are fulfilled, within the constraints of capital, time, and various other resources.

An engineering project is characterised by the fact that it involves at least a single definable end-product; that it cuts across organisational lines; that it is a unique, one-time activiity; that it involves unfamiliarity, uncertainty, and risk; that it is a temporary activity; and that it passes through several distinct phases comprising the project life-cycle. The complexity of modern projects,in terms of the magnitude of efforts, the number of groups/organisations involved, and the diversity of expertise required, is perhaps reflected in the uncertainty experinced in predicting the final outcome of the project in terms of cost time, and performance. The role of project managemnt is to integrate resources and tasks to achieve organisational goals, and this role can be viewed in terms of planning, organising, leadership, control, and the management of change.

CHARACTERISTICS OF PROJECT MANAGEMENT

Some of the typical characterstics of project management are:

(i) A project manager is the focus of responsibility, authority, and accountablity for the project, and he may operate independently of the normal chain of command in the organisation.

(ii) The various tasks may be accomplished by specialists from different functional departments/groups, with a horizontal integration of resources and responsibilities.

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(iii) While the functional groups/departments may be permanent, the project team is temporary, and is to be disbanded or regrouped at the end of the project.

(iv) The project focuses on delivering a specified product or service at a pre-dermined cost and time.

(v) The project management function sets in motion other support services. such as personnel, finance and accounts, purchase, information systems, etc.

The major feature distinguishing project management from functional management (such as personnel, finance, marketing, etc.) is the emphasis on overall project goals vis-a-vis the individual functional goals. In systems parlance, project management involves the use of a "wholistic" approach to design , build, and commission engineering systems, that involves formal consideration of:

(i) Total system objectives (performance measures);

(ii) System environment (fixed constraints);

(iii) System resourses (inputs);

(iv) System components (activities, goals, performance); and

(v) System management (component interactions)

SYSTEM DESIGN

An important precursor to project management is a formal systems design technique, wherein a broad and primative need is translated into a detailed engineering statement of the problem; thereafter, a feasibility study is conducted to identify a feasible and optimal solution. Systems design is thus a technique in which various engineering techniques and scientific principles are utilised to:

(i) select materials and components;

(ii) organise these elements; and

(iii) establish operational procedures to create a system which is the optimum (or near optimum) solution to the real needs of a particular situation.

Quantitative methods or systems and procedures for an overall project management systems ensure that the overall project goals are translated into short-term objectives (plans, schedules, and budgets),and that necessary controls are engineered to ensure that the plans are executed (project control evaluation, reporting, and termination). An overall project summary plan or master plan would comprise of an introduction (definition of the project), a management summary (overveiw for top management), the management and organisation of the project (key personnel and authority lines), and the technical details and scope of work (work breakdown structure, network schedule,cost estimates and budgets, and implementation and control).

WORK BREAKDOWN STRUCTURE

In the work breakdown structure (WBS), a level-by-level breakdown of the total project is undertaken, untill all the requried tasks/work packages are identified in such a manner that the time, cost, and performance requirements of each work package can be accurately determined. These work packages form the "building blocks" of the total project, and are the basis for project scheduling, costing and budgeting, and implementation and control.

Project scheduling can be accomplished by a simple tabulation of the work packages and their schedules, or by more formal methods such as the Gantt chart, PERT or CPM techniques. In either case, it is helpful to flag milestone events, which signify important occurrences in the project, such as the completion of major phases of project, or events where payment is linked to the completion of critical tasks.

GANTT CHART

The Gantt chart is a pictorial representation of the project schdule, using horizontal bars to show the scheduled start and completion time of all the activities/work packages. Though simple to use, Gantt charts can be quite effective for monitoring the progress of work in a project However, Gantt charts do not show either the relationships amongst the work packages, nor the impact of delaying activities or shifting resources on the over-all project schedule.

PERT AND CPM

Planning and scheduling methods using network analysis sonsist of primarily the Programme Evaluation and Review Technique (PERT) and the Critical Path Method (CPM). Project network diagrams can be either Activity-On_Node (AON) or activity-On-Arc (AOA), with the latter being more widely used. In PERT, the emphasis is on project schedule alone, with alternate approaches being in terms of a simple-estimate or a three estimate approach for the activity schedules. PERT is generally suitable for research, design, and development projects, where there may be considerable uncretainties in estimating the activity time requirements, and where cost considerations are not explicitly accounted for.

Since the availability of resourses (captial, equipment, labour) is often a major determinant of the project schedule, project managers should strive for "constrained resource planning", i.e., examine the trade-offs between project schedules, costs, and resource utilisation. The critical path method (CPM) provides an effecient way of considering resourses as scheduling constraints, and is widely used in construction, diversification, and modernisation projects. This method gives a mathematical procedure for estimating the time-cost "trade-off" for the project,viz. the reallocation of resources from one activity to another, so as to achieve the maximum quickening of the project schedule for the minimum project direct cost. Algorithms are also avilable for two types of resource related problems, namely resource leveling (i.e. balancing a given resource utilisation throughout the project), and resourse loading (i.e., limiting the utilisation of a given resource to a pre-specified maximum value).

COST ESTIMATES

Besides work defination and work scheduling, the two other major focal points of project planning are cost estimating and budgeting. Estimates for project cost are based upon the work packages identified in the WBS. The initial cost estimate can seal a project's fate: if overestimated, the contract may be lost; if underestimated, problems may arise during the execution of the project. Normally, project schedules determine the rates of expenditures and cash flows; however, the converse may also be true - when working captial and other resourses are limited, project schedules must be adjusted accordingly.

Project cost estimates and budgets share most (or all) of the following elements:

(i) Direct labour (staff) expenses;

(ii) Direct nonlabour (materials/facilities) expenses;

(iii) Overheads;

(iv) General and adminstrative expenses; and

(v) Profits.

PROJECTS CONTROL

Project control is the process of keeping the project on target, and as close to the project plan as is feasible. In general, project control is achived in three phases:

(i) Setting performance standards - in terms of technical specifications,

budgeted costs, schedules, and resource requirements;

(ii) Comparing standards with actual performance - in terms of schedules, budgets, and performance specifications; and

(iii) Taking corrective action - whenever the actual performance significantly deviates from the specified standards, either the work is altered or expedited, or the plans and standards are revised.

In traditional cost control, the project performance is measured by cost variance analysis. This involves a comparison of the actual costs with the budged costs, to see if the money spent was more or less than planned. However, since cost is only one dimension of the project performance (with schedule and technical performance being the other major indicators), a combined cost, schedule and technical analysis is a necessary part of project control.The cost and the schedule analysis using the "earned value concept" involves computation of the budgeted cost of the work performed (as of the date of review), and comparing it to the budgeted cost of the work scheduled, as well as to the actual cost of the work performed. The accounting variance, schedule variance, time variance, and cost variance give a comprehensive picture of project performance; the same can be summarised in terms of the schedule performance index and the cost performance index.

ORGANISATION

Finally, the design of a project organisation and the streamlining of authority, accountability, and responsibility depend on the organisation's goals, the type of work, and the environment. In general, it is helpful to keep in mind the following five principles of participative management, vis-a-vis the project staff:

(i) Being in the know of things - or the feeling of inclusion;

(ii) Being heard - or the feeling of recognition;

(iii) Having a say - or the feeling of power;

(iv) Taking decisions - or the feeling of authority; and

(v) Seeing to implementation of decisions - or the feeling of achivement.

CONCLUSIONS

(i) Modern engineering projects require a systematic and scientific approach towards managing them;

(ii) System design techniques can be used to translate a primative need to a feasible, optimal solution;

(iii) The key elements of engineering project management include the Work Breakdown Structure (WBS),Gantt chart, PERT/CPM, cost estimation and budgeting, and project implementation and control; and

(iv) The use of the techniques, in an integrated systems approach to project management, will help in reducing cost and time over-runs in modern engineering projects.

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