PROJECT MANAGEMENT TECHNIQUE

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PREFACE

The subject of project management which is concerned with planning, scheduling, and controlling of nonroutine activities within certain time and resource constraints includes a wide range of topics. Hundreds of articles and papers and several books have appeared relating to network planning and critical path analysis. Network planning, scheduling, and control systems offer tremendous potential for future exploitation. All their past and present uses build a solid foundation for radical innovation in project management concepts.

This book is not intended as an exhaustive treatise. Instead its purpose is introductory, aimed at serving two types of readers: first, the beginning or practicing project manager in the field who is not thoroughly familiar with modern techniques of network analysis, and second, those senior or graduate students who elect to study the subject of project management and related questions.

The book focuses on basics and presents the essentials in a simple, straightforward manner, so that it can be used as an individual guide to planning, scheduling, and controlling techniques in project management.

Chapters 1 through 8 cover the concepts and techniques of project management. Emphasis is placed on a systematic treatment of the subject. The general tone for this text is to address the need for procedures which allow projection of the possible future stages of a project through to completion. Chapter 9 addresses the subject of project proposals—this

is considered important, since it serves as a framework for developing a detail plan and schedule to be used in carrying out a project. In chapter 10, discussion focuses on project personnel selection; the author believes that one of the first and most important ingredients of any successful project is the selection of the right project manager, since each project has a unique set of circumstances that tend to demand a unique set of qualifications in its manager.

Chapter 11 deals with various types of contracts likely to be selected by a customer as the most feasible for a contemplated procurement. Chapter 12 presents a television tower and building project. Chapter 13 follows this up by treating a project management simulation; this device allows the project manager or student to participate in a dynamic interactive way, whereby the student plans the project prior to its beginning and then he or she directs the project as it unfolds in response to a series of unpredictable and randomly introduced variables that cause the project situation to change as time progresses. The author believes that this procedure would allow the student the opportunity to assume the role of the project manager in making decisions throughout the duration of the project, and will also provide the student with an in-depth examination of the concepts and techniques discussed in the text.

Chapter 14 presents various case studies, which can be used as class projects. Appendix A addresses the normal distribution and illustrates the significance of the mean of standard deviation. Appendix B explains the activity-on-arrow system of networking and a procedure for converting from activity-on-node system (which is used in the text) to activity-on-arrow system. Appendix C discusses the event-oriented systems, and comparision is made with the activity-on-node and activity-on-arrow systems. Appendix D presents a listing of table of random numbers. Finally, Appendix E stresses a computer method.

Emphasis throughout the text is on questions, e.g., planning, scheduling and control techniques, which can be described by project evaluation and review technique and critical path method. The author, with some regrets, has not heavily emphasized certain topics to which a decided emphasis has been given in the literature; this has been largely the result of the nature of his own particular experience rather than an intention to slight such material.

The intent of the author has been as, a minimum goal, to present a resumé of representative management practices in the project management field.

This text is dedicated to Denise for her encouragement, patience and lost weekends, and to my parents, sisters, and nephew Leo for their inspiration.

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NOMENCLATURE

a	Optimistic time
A-O-A	Activity-on-Arrows
A-O-N	Activity-on-Nodes
b	Pessimistic time
C_c	Crashed activity cost
C_D	Drag Coefficent
C_n	Normal activity cost
C.O	Crane Operator
CPM	Critical Path Method
CUMUL.	Cumulative
d_f	Flap deflection
DPC	Direct Project Cost
EF	Earliest Finish Time
ES	Earliest Start Time
FF	Free Float
IPC	Indirect Project Cost
K	Crashing cost for each activity
LF	Latest Finish Time
LS	Latest Start Time
m	Most probable time
M	Maximum possible activity time reduction due to crashing

PERT	Project Evaluation and Review Technique
Prob.	Probability
R & D	Research and Development
SD	Standard Deviation
t	Activity completion time
T	Project Completion Time
τ	Normal activity time
τ'	Crash activity time
TF	Total Float
TV	Television
V	Project time variance
v	Variance of the activity time

CONTENTS

Chapter 1
INTRODUCTION TO PROJECT MANAGEMENT

Network-based procedures of PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) are well known and widely used to assist managers in planning and controlling both large and small projects of all types (construction, research, development projects, and many others).

Many managerial problems in the areas of project scheduling and control have been solved successfully with the aid of network models and network analysis techniques. Effective planning and scheduling are absolutely essential to the success of these types of activities.

The words "planning" and scheduling" are common to completely different problems. For many years considerable operations research activity has been spent in the area of "production scheduling." In general, the techniques developed for this area are directed toward solving for sequences that minimize man or machine idle time subject to constraints. In most cases this effort has been primarily concerned with repetitive activities generally in continuous-flow production situations. Only recently has any significant effort been devoted to the study of the planning and scheduling problems of the class of operations known as projects or one-time operations.

The need for procedures which allow projection of the possible future stages of a project through to completion led to the adoption of the network as a desirable means of depicting the elements of a project and the relationships among them. This network idea is the basis of all critical

path analysis schemes and is used to depict a project plan. Much of the early success of PERT/CPM was based on the explicitness of the project plan, this explicitness being essential to the construction of a network. Being explicit about what was to take place at some later time was a new experience for many. Improved communications among those concerned with a given project were common results of networking the project plan.

Among the many operations that may be classed as projects are heavy and light construction, facilities maintenance, shipbuilding, the research and development phases of military weapon systems acquisitions, indeed any set of activities requiring a one-time oriented coordination of men, equipment, and materials. These operations tend to have several things in common, such as:

1. The end products of each operation are few in number.
2. Each operation is composed of a large number of serial and parallel jobs.
3. All of these jobs are directed toward a common objective.
4. A significant amount of uncertainty exists regarding the exact manner in which the objective is to be accomplished, how long it will take and how much it will cost. The degree of uncertainty with which each operation is perceived will vary depending on such factors as the state of the technology employed and the number of times similar operations have been performed in the past.
5. Different jobs are done by different organizations which have difficulty communicating with each other.

Planning and scheduling have always played an important role in project-type operations. However, most earlier planning systems had deficiencies resulting from the use of techniques which were inadequate for dealing with complex projects. Generally, the several groups concerned with the work did their own planning and scheduling. Since much of this was independent, the results often reflected a lack of coordination in carrying out the work. In addition, it is traditional in project operations to develop detailed schedules from gross estimates of total requirements and achievements based on past experience. Plans and schedules based on this data tend to consider all the pertinent factors bearing on the problem at one time.

The lack of adequate tools and techniques has been primarily responsible for these conditions. Most of the traditional scheduling techniques are based on the Gantt or bar chart which has been in common use for over 50 years. Although it is still a valuable tool, its use is limited in the scheduling of large-scale operations. In particular, the bar chart fails to delineate the complex interactions and precedence relationships which exist among the project activities. The milestone system used extensively by the military and industry for the management of major projects prior to the advent of PERT was an important link in the evolution from the Gantt chart to the network concept. Milestones are key events or points in time which can be uniquely identified when reached as the project progresses. The milestone system provides a sequential list of the various tasks to be accomplished in the project. This innovation was important because it emphasized the functional elements of the program, reflecting what is now the project work-time breakdown or product indenture structure. This system increased awareness, if not the effective display, of the interdependencies between tasks.

While the milestone system has the limitation that the relationship between milestones is not established, it is still widely used usually as an adjunct to the network system. Milestones are merely listed in a chronological sequence and are not related in a logical sequence of work required to accomplish them. Therefore, the essential interrelationships cannot be displayed. The system was an important early recognition of the need for awareness and discipline at lower management levels and forces outcome-oriented planning of all the segments of the projects.

Network planning, scheduling, and control systems offer tremendous potential for future exploitation. All their past and present uses build a solid foundation for radical innovation in project management concepts. The literature is already filled with examples of vastly improved planning by applying trade-off or optimization techniques to time, dollars, and labor. However, the ability to allocate resources over multiple projects means that it is possible to develop a total corporate planning system.

Future projections with network systems are no longer theoretical topics, and they offer significant long-range benefits to business management. The relationship of the network system to the management function and the outlook for further development of the system, perhaps even leading to a valid general system theory for the management of human enterprises, is extremely promising.

SUCCESSFUL IMPLEMENTATION

A decision by an organization to initiate a critical path scheduling system usually requires some form of training for the firm's personnel and for representatives of cooperating companies. Training may take the form of a brief indoctrination session, a detailed short course, or on-the-job training. Unquestionably, the detailed short course followed by a formal on-the-job training program best ensures success for the new system.

ROLE OF NETWORKS IN A PROJECT MANAGEMENT SYSTEM

The network models are means of describing a particular project plan in a manner such that evaluation is not only possible but is in fact a logical extension of the model. A given model of this basic type will describe *one* alternative project plan. Other models will be required if other alternatives are to be examined.

The network concept involves the graphical representation of activities and their precedence requirements. Activities are elements of the project which represent logical subdivisions of the work to be done. If you considered preparing breakfast as a project, pouring a cup of coffee could be an activity. The level of detail used depends upon the degree of control desired. As an extreme example, if control is desired only on the start of a project, the entire project may be described as a single activity. Precedence requirements indicate which activities must be completed before a given activity can proceed. The network may be thought of as indicating the time flow of work involved in the project. The network is *not* a schedule. It is not necessary to know the estimated time duration of activities before networking the project. In fact, this property makes it possible to separate the network modeling process from all other aspects of the planning phase. The likelihood that innovative and effective plans will be produced is improved by the use of the time-free networking process.

The basic purpose of the network is to provide a comprehensive picture of the precedence relationships existing among activities. Precedences are determined by comparing the environments created by the completion of an individual activity in the project with the environment necessary for the start of the succeeding individual activities. Resource availa-

bility and customary practice are not to be considered as creating precedence relationships. Both of these factors can be considered later during the scheduling phase, but inclusion in the planning phase may preclude the possibility of eventually arriving at the best schedule.

There are two basic systems of networking currently in use. The arrow diagramming, or activities-on-arrows (A-O-A) system, is more widely used, but the precedence diagramming, or activity-on-nodes (A-O-N) system, is growing in popularity and has significant advantages. *The A-O-N precedence diagramming system is used throughout this text.* The activities-on-arrows (A-O-A) system is explained in Appendix B and a procedure for converting from A-O-N to A-O-A is given.

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