PROJECT MANAGEMENT HANDBOOK

Edited by

David I. Cleland

William R. King

PROJECT MANAGEMENT HANDBOOK

Edited by

David I. Cleland

Professor
Engineering Management
School of Engineering
University of Pittsburgh

William R. King

Professor of Business Administration
Graduate School of Business
University of Pittsburgh

VAN NOSTRAND REINHOLD COMPANY
NEW YORK CINCINNATI TORONTO LONDON MELBOURNE

Library of Congress Catalog Card Number: 82-7030
ISBN: 0-442-23878-9

Manufactured in the United States of America

Published by Van Nostrand Reinhold Company Inc.
135 West 50th Street, New York, N.Y. 10020

Van Nostrand Reinhold Publishing
1410 Birchmount Road
Scarborough, Ontario M1P 2E7, Canada

Van Nostrand Reinhold
480 Latrobe Street
Melbourne, Victoria 3000, Australia

Van Nostrand Reinhold Company Limited
Molly Millars Lane
Wokingham, Berkshire, England

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging in Publication Data

Main entry under title:
Project management handbook.

Includes index.
1. Industrial project management—Addresses, essays, lectures. I. Cleland, David I. II. King, William Richard, 1938–
HD69.P75P75 1982 658.4'04 82-7030
ISBN 0-442-23878-9 AACR2

Preface

The purpose of this handbook is to provide project managers and those individuals concerned with project management in both public and private organizations a reference guide for the fundamental concepts and techniques of managing projects.

Like all good handbooks, this is a reference source for practical how-to-do-it information. A manager or professional who has a problem with project management can turn to this handbook and find the help needed to solve the problem.

However, there are other important uses to which this handbook can be put. The field of project management has been growing so rapidly in recent years that anyone who wishes to learn more about the discipline is faced with an abundance of published information. The handbook contains the writings of an uniquely qualified group of people who have made significant contributions to the theory and practice of project management.

Thus, in such a rapidly developing field, even experienced project managers are faced with the challenge of keeping up with current developments and selecting those concepts and techniques that are most appropriate for their needs.

Those who are not experienced project managers, but who must play a role in the process of project management—functional managers, general managers, project team members and support staff—have an even more difficult task, for they must "keep up" in a rapidly expanding field that is not their special area of expertise. So, the *Project Management Handbook* is also addressed to their needs.

Students of project management may use the *Handbook* as a self-study aid, for it has been organized to facilitate an overall program of learning about the field as well as to provide a quick reference source on specific topics.

The *Project Management Handbook* seeks to provide guidance for all varieties of projects—from the largest and most complex systems development efforts, to the personal "research project." Its emphasis, however, is organizational in the sense that much of the material deals with the integration of projects into an overall managerial framework.

In addition to serving the needs of those who are directly concerned with project management, this book will be useful to top managers who wish to motivate and establish a philosophy of project management within their orga-

nizations. There are different types of project management, ranging from the simplistic use of expediters to sophisticated multiproject organizational approaches. the high-level manager who believes that one of these forms will be useful will find the *Handbook* to be a sound guide for planning for the evaluation of project management in the organization.

The handbook provides information on both the theory and practice of project management. While primary emphasis is on the pragmatic aspects of managing projects, this pragmatism is casted in a sound, theoretical framework of managerial thought.

In the editors' opinion, the proportion of project participants who require access to a handbook in this field is greater than for any other managerial group. This is because of the relative newness of the field, the lack of adequate training programs, and the general awareness that, unlike some other disciplines, there is a practical body of knowledge which can serve to support all aspects of the project management process.

As one leafs through the pages of the *Project Management Handbook*, the number and variety of the factors and forces with which the project manager must deal become clear. Their very number appears at first to make it impossible for one individual to master the art and science of managing projects. However, in reading further one becomes aware of the creativity and ingenuity which the authors have brought to bear on project management. For most of the problem situations that a project participant will face, this handbook has information that can be of help. Certainly, no one would claim that the state-of-the-art of this field has stabilized. Further evolution will continue. Nevertheless, the reader will find that there are workable solutions to the situations that arise in project management.

This handbook is the result of the cooperative efforts of a large number of people. The qualifications of the individual contributors are clear from the biographical sketch given on the title page of each article. The topic content of the handbook is broadly designed to be relevant to the general organizational contexts in which project management is found. Accordingly, some of the parochial subjects of project management in specific industries are not included. For example, configuration management and value engineering—two key concerns of project managers in the aerospace industry—are not treated. The editors believe that the parochial interests of a particular industry's project manager's needs can be best served by studying the literature of that industry.

Whatever its value to the reader, the *Project Management Handbook* reflects the experiences and considered judgments of many qualified individuals about the pivotal factors and forces surrounding project management. Eight interdependent areas of project management are developed:

1. *An Overview of Project Management.* The framework of practice and theory in which contemporary project management is found.

2. *Project Organization* The alignment of resources to support project objectives, particularly in terms of the matrix organization.
3. *Organizational Strategy of Project Management.* The deployment of resources to support broader organization missions, objectives, and goals.
4. *Life Cycle Management* The management of projects as they fit into broader and longer-range organizational purposes.
5. *Project Planning.* Planning to include the development of goals, strategies, and actions to allocate project resources.
6. *Project Control.* The means to determine the harmony of actual and planned cost, schedule, and performance goals.
7. *Behavioral Dimensions of Project Management.* The development of a climate whereby the project people work together with economic, social, and psychological satisfaction.
8. *The Successful Application of Project Management.* An examination of what counts for success in project management.

We thank the contributing authors who have given so importantly and unselfishly through their practical how-to-do-it presentations of the forces and factors involved in project management.

The editors are deeply indebted to Claire Zubritzky, who managed the administration involved in the development and production of this handbook. We are also indebted to Olivia Harris, whose contributions, both to the *Handbook* and to the milieu in which we work, were substantial.

We thank Dr. Albert G. Holzman, Chairman of the Industrial Engineering Department, Dr. M. L. Williams, Dean of the School of Engineering, and Dr. H. J. Zoffer, Dean of the Graduate School of Business, all of the University of Pittsburgh, who provided us with the environment to pursue this effort.

Contents

SECTION IV / LIFE CYCLE MANAGEMENT

SECTION V / PROJECT PLANNING

SECTION VI / PROJECT CONTROL

Section I

Overview of Project and Matrix Management

This introductory section of the handbook presents an overview of project and matrix management. Project management is viewed as a powerful tool that is particularly useful in terms of the management of the many interfaces that exist within an organization, and between an organization and its environment.

However, despite the power of the concept and its history of successful application, project management is not presented as a panacea. Rather, it is a tool which, *when properly used under appropriate circumstances,* can aid the organization in the achievement of its major goals.

In Chapter 1, Peter W. G. Morris explains the need for project and matrix management in an insightful chapter on "interface management." He discusses project and matrix management in conceptual terms and provides, as well, numerous real-world illustrations and prescriptions for the successful management of interfaces.

In the second chapter, Linn C. Stuckenbruck discusses project integration in the matrix organization by emphasizing the proactive nature of integration; that it does not just happen, but must be made to happen. He discusses how a project management system can be implemented in the organization and what the project manager must do to properly begin the project.

In Chapter 3, Arthur G. Butler, Jr. discusses the pros and cons of project management by reviewing the evolution of the project management concept, the uses to which it has been put, and its alternatives. He emphasizes both the functional and dysfunctional potentials of project management in a variety of dimensions such as conflict, patterns of interaction, power, status, influence and control.

1. Managing Project Interfaces—Key Points for Project Success

Peter W. G. Morris

One of the most important qualities of a project manager is a mature understanding of the way projects develop. This allows the nature of project activities to be better understood, problems to be seen in perspective, and needs to be assessed ahead of time.

To some extent this understanding of project development is intuitive, though it clearly also depends upon specialist knowledge of the project's technology and industry. It can, however, also be acquired in large part from formal study of the development process of projects, since all projects, regardless of size or type, follow a broadly similar pattern of development.

The organizational framework underlying a project's development is the subject of this chapter. The intent of the chapter is to illustrate the types of issues that are normally encountered as a project develops and to suggest ways in which these issues should be handled.

THE SYSTEMS PERSPECTIVE AND PROJECT MANAGEMENT

The chapter employs a systems framework: project structure is divided into major systems components, and the management of these components is looked at from a systems perspective. What is the systems approach?

A system is an assemblage of people, things, information, etc., grouped together according to a particular system "objective." Thus, one has the elec-

---

Peter Morris undertook research into project management at Manchester University, England in the late 60's, gaining his Ph.D. in 1972. He has worked both as a manager and as a consultant on a variety of projects around the world ranging from telecommunications and petrochemical projects in the Mid East, North Africa and Europe, steel projects in Latin America, and construction, MIS and aerospace projects in North America and Europe. Dr. Morris specializes in project planning, organization and control at the Arthur D. Little Program Systems Management Company, Cambridge, Massachusetts.

trical system, the digestive system, a high pressure weather system, an air conditioning system, a weapons system, a system for winning at cards.

A system may be logically broken down into a number of subsystems, i.e., assemblages of people, things, information, or organizations required to achieve a defined system *sub*-objective, like the switching, outside plant, building, transmission, and subscriber subsystems in a telephone system. The subsets of each subsystem may then be identified—cables, poles, microwave, and transmission and distribution equipment for the transmission subsystem—thereby creating sub-subsystems. Subsets of these subsets may then be identified, and so on.

Properly organized and managed, the overall system acts in a way that is greater than the sum of its parts. The systems approach emphasizes treating the system as a whole.

The systems approach has its origin in the late 1920s and 1930s. Biologists noticed similarities in the way that living organisms interacted with and controlled their environments. Similar patterns were simultaneously observed, by Gestalt psychologists, in the way the human mind organized sensory data. Both the mind and living organisms have to adapt to changes in their environment. Systems of this type are known as "open" systems. Before long it was seen that all social systems operate as open systems.[1]

During the 1950s, work in economics, psychology, sociology, anthropology and other disciplines developed these open system ideas by elaborating such concepts as self-organization, purposive systems, the importance of goals and objectives, the hierarchical classification of systems and subsystems, and the importance of systems' boundaries and interfaces (2)*. At the same time, this "systemic" view of the world was enriched by a parallel (but initially separate) set of disciplines which had their origin in the industrial and military applications of the scientific method during and immediately after World War II. This was the essentially numeric set of disciplines, such as cybernetics, control theory, operations research, systems analysis and systems engineering, concerned with modelling real life situations so that complex behavior could be more accurately described and forecast. Slowly both streams merged, encouraged

[1]Open systems are "open" to the effects of their environment. On the other hand, closed systems, which are the other major system type (including for example, much of physical chemistry and many types of machines), operate independently of their environment. In open systems, events rather than things are structured; there is a constant energy and information exchange between the system and its environment; the system organizes to minimize entropic decay; equilibrium with the environment is achieved through a process known as homeostasis; and there is a tendency towards differentiation. Closed systems operate in almost exactly the opposite manner (1).*

*Numbered references are given at the end of this chapter.

greatly by the enormous growth in the ability of the computer to apply these systems ideas with powerful effectiveness, so that the systems approach is now an established and vigorous influence on management and research.

The systems perspective has contributed substantially to the development of project management. Most importantly, the emphasis on viewing a system as a whole has frequently been behind the recognition of the need for an across-the-board integrating role—i.e., for project management itself (3).[2]

Secondly, systems thinking has shown how projects should work as successfully regulated organizations—the need for clearly defined objectives, the recognition that projects are organizations in constant change and the need to define and manage the major subsystems and their interfaces. A third important contribution is that the dynamic control needs of projects are now better understood—the importance of feedback, the progressive development of information and multilevel project control. And a fourth contribution is the widespread use of systems techniques—systems analysis, systems engineering, work breakdown structures, and simulation models.

Interface Management, as it is used in project management today,[3] is an outgrowth of the first two of these influences of systems thinking on project management. Interface Management identifies:

- The subsystems to be managed on a project.
- The principal subsystem interfaces requiring management attention.
- The ways in which these interactions should be managed successfully.

The emphasis on identifying key interfaces and on focusing on interface performance has grown as it has been increasingly realized that all projects share a common pattern of interfaces derived from a common pattern of subsystem

---

[2]The development of project management by the U.S. military is an illustration: the systems ideas developed initially for technical purposes were adapted to generate the organizational flexibility and control missing in the existing military bureaucracy. This can be seen in each of the steps in the U.S. military's development of project management—the Atlas Program, begun in 1954; Peck and Scherer's study of the US and Soviet weapons procurement processes in the late 1950's (4); the development of PERT by the US Navy in 1958, the introduction of project organizations in the Navy, Air Force and Army in the late 1950s/early 1960s; McNamara's extensive study and implementation of program management and project control techniques in the early 1960s; and Laird's and Packard's process-oriented focus on the needs of the total project lifecycle in the late 1960s/early 1970s.

[3]Interface Management is generally used now in a broader sense than it was ten or twenty years ago. In the 1960s and early 1970s Interface Management generally referred simply to ensuring that system interfaces matched (i.e. had the same specifications, were not missing any equipment, data etc.) Today it is used in the sense of defining systems—organizational, managerial and technical—and of actively managing their interrelationships.

interaction.[4] This is true no matter what the type of project, be it a theater production or an aid program, an election or a major capital investment program.

There are three sets of subsystems on any project: those deriving from the project's life cycle, its management levels, and its operational characteristics.

PROJECT LIFE CYCLE

Project management teaches that to achieve the desired project objective one must go through a specific process. There is no exception to this rule. The process is known as the project "life-cycle."

Projects (like people) have a life-cycle that involves a gradual buildup as definitions are established and working characteristics developed, a full-bodied implementation as the work is accomplished, and a phasing out as the work is completed and the project winds down. This cycle (Figure 1-1) is invariant, although (as with people) sometimes not fully recognized or respected.

A project starts as an incipient idea which is explored for financial and technical feasibility in the *Feasibility Stage.* Capacity is decided, locations chosen, financing arranged, overall schedule and budget agreed, and preliminary organizations set-up. At the end of the first phase there is usually a formal "go/no-go" decision. In the second, *Design,* phase, the work is organizationally and managerially similar to the first phase, only it is more comprehensive and detailed. The technical definition of the project is expanded (albeit generally still at a fairly strategic level); schedule, budget and financing is reappraised; contracting strategy is defined; permits are sought; and infrastructure and logistics systems are defined.

In phase three, *Manufacture, Construction and Installation* (often called *Production*), equipment is procured, civil work is undertaken, and equipment and facilities are installed. This phase differs dramatically from the previous two. First, whereas the *Design* and *Feasibility* phases were organic and evolutionary in character, the *Production* phase is highly mechanistic (5). The aim is not to develop new technical options but to build as efficiently as possible the thing which has been defined in the *Design* phase. Second, there is a large—often vast—expansion in organization (whereas there may have been only dozens or hundreds of persons active in the first two phases, there may be thousands or even tens of thousands involved in this third phase.) And third, the

[4]Note that an interface is technically defined as the space between interacting subsystems. Even though there might be a common set of subsystems on all projects, this does not necessarily mean there will be a common set of interfaces. The extent that there is depends on the commonality of subsystem interaction. This chapter will show that subsystem interaction does in fact follow a common pattern on most projects.

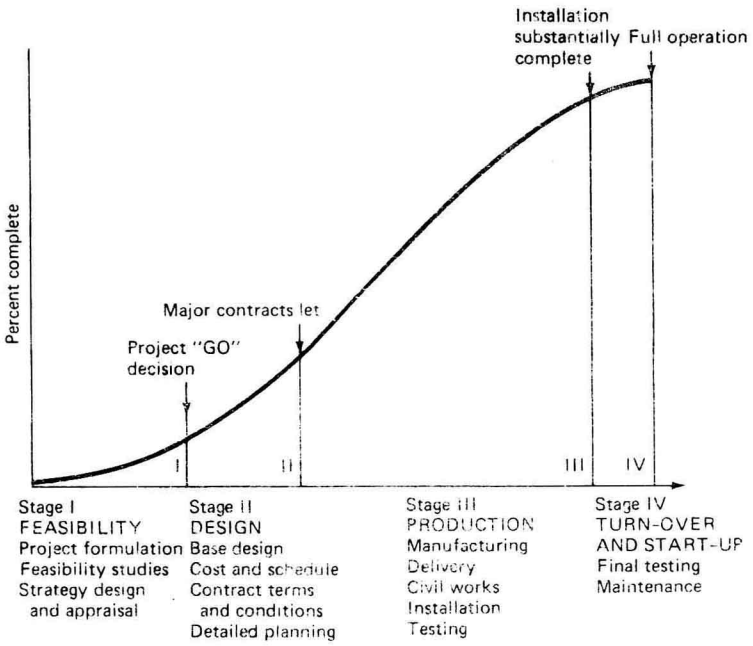

Figure 1-1. Project life cycle.

characteristic mode of control changes from one of "estimating" costs and durations to one of tight "monitoring" of quality, schedule and cost to keep actual performance within the target estimates.

The fourth and final phase, *Turn-Over and Start-Up*, overlaps the third phase and involves planning all the activities necessary for acceptance and operation of the project. Successfully synchronizing phases three and four can prove a major management exercise. The cost of capital locked up in the yet uncommissioned plant, and the opportunity costs of both, underutilized operating systems such as sales, operating plant, personnel etc., and a possible diminishing strategic advantage while competitors develop rival products can prove enormous.

Between each of these four life-cycle phases there are three distinct "change points" (what shall later be called "dynamic project interfaces"):

- From *Feasibility* to *Design*: the "go" decision.
- From *Design* to *Production*.
- From *Production* to *Turn-Over & Start-Up*.

The project on either side of these change points is dramatically different—in mission, size, technology, scale and rate of change—and these differences cre-

ate their own particular different characteristics of work, personal behavior, and direction and control needs. Thus, importantly, the management style of each of the four main life-cycle phases is significantly different.

PROJECT MANAGEMENT LEVELS

The four phases have a set and important managerial relation to each other. The work of the *Feasibility* stage is highly "institutional" (top management) in kind—decisions taken in this phase will later have an overriding impact on the health of the investing enterprises. In *Design* the work is of a "strategic" nature, laying the axes upon which the detailed, "tactical" work, of the third, *Production* phase will rest. Interestingly, the fourth phase, *Turn-Over & Start-Up*, exhibits a mixture of all three managerial levels of work: institutional, strategic and tactical.

These three levels of management activity have been recognized as distinct levels of management since at least the time of Talcott Parsons, the eminent American sociologist. Parsons made the point that each of the three levels has an essential role to play in any successfully regulated enterprise: the technical/tactical level (III) manufactures the product, middle management (II) coordinates the manufacturing effort, whilst at the institutional level (I) top management connects the enterprise to the wider social system (6). Each of the three has a fundamental role to play in the management of every project (although it is true that the levels tend to become more blurred on the smaller projects). Yet surprisingly most project management literature deals only with Levels II and III. There is little in the literature that treats such Level I issues as: the role of the owner and his financer; relations with the media, local and federal government, regulatory agencies, lobbyists and community groups; the sizing and timing of the project in relation to product demand and the cost of finance—all issues that became crucially important during the 1970s.

The distinction between Levels II and I is quite critical since it is essentially the distinction between the project and its outside world (Figure 1-2). Levels II and III deal almost exclusively with such familiar project activities as engineering, procurement, installation, testing and start-up—Level III providing the technical input, Level II providing both a buffer from the outside world and guidance in how to avoid external pitfalls. But no project exists in isolation from outside events. Level I provides the coordination of the project with outside events and institutions. Level I actors typically include the project owner and his finance team, government agencies, community groups, very senior project management and one or two special project executives specifically charged with external affairs, such as Public Relations and Legal Counsel.

The involvement of each of these Levels is different during each of the major phases of the project life-cycle. During the *Feasibility* stage, the owner and his