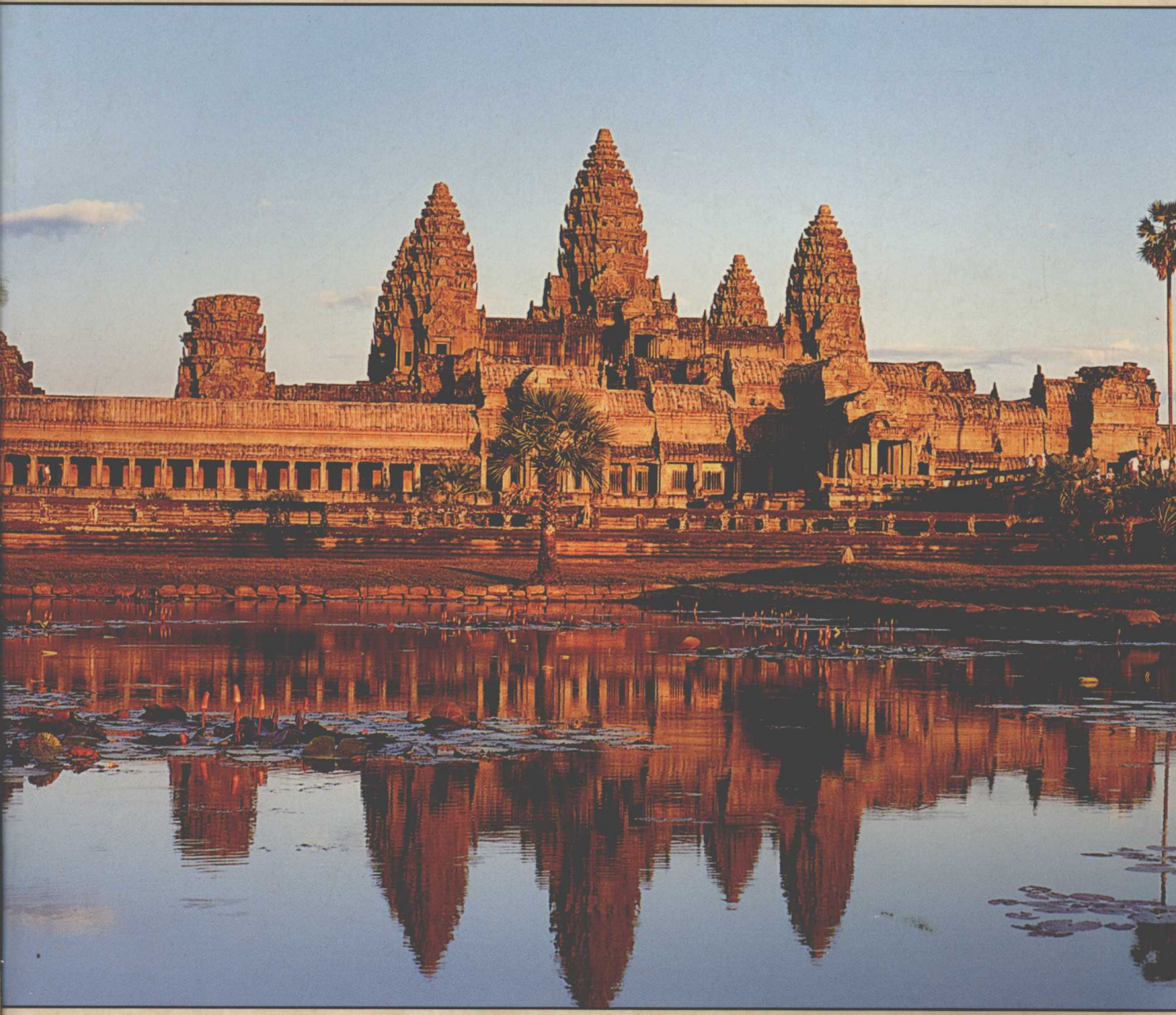
PROJECT MANAGEMENT

Processes, Methodologies, and Economics

SECOND EDITION



Avraham Shtub · Jonathan F. Bard · Shlomo Globerson

Project Management

Processes, Methodologies, and Economics

Avraham Shtub
Faculty of Industrial Engineering and Management
The Technion–Israel Institute of Technology

Jonathan F. Bard
Department of Mechanical Engineering
Graduate Program in Operations Research & Industrial Engineering
University of Texas at Austin

Shlomo Globerson
School of Business Administration

Upper Saddle River, NJ 07458

Library of Congress Cataloging-in-Publication Data

Shtub, Avraham
Project management Processes, methodologies, and economics / Avraham Shtub, Jonathan F Bard, Shlomo Globerson --2nd ed
p cm -- (Prentice-Hall international series in industrial and systems engineering)
Includes bibliographical references and index.
ISBN 0-13-041331-3
1 Engineering--Management 2 Project management I Bard, Jonathan F II Globerson, Shlomo, 1941- III Title. IV Series.

TA190 S59 2005
658 4'04--dc22

2004057264

Vice President and Editorial Director, ECS· *Marcia J Horton*
Vice President and Director of Production and Manufacturing, ESM *David W Riccardi*
Acquisitions Editor *Dorothy Marrero*
Editorial Assistant *Richard Virginia*
Executive Managing Editor *Vince O'Brien*
Managing Editor *David A George*
Production Editor *Kevin Bradley*
Director of Creative Services *Paul Belfanti*
Art Director. *Jayne Conte*
Cover Designer *Bruce Kenselaar*
Art Editor *Greg Dulles*
Manufacturing Manager *Trudy Pisciotti*
Manufacturing Buyer. *Lynda Castillo*
Senior Marketing Manager *Holly Stark*

Pearson Prentice Hall
Pearson Education, Inc
Upper Saddle River, NJ 07458

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-041331-3

Pearson Education Ltd , *London*
Pearson Education Australia Pty. Ltd , *Sydney*
Pearson Education Singapore, Pte Ltd.
Pearson Education North Asia Ltd , *Hong Kong*
Pearson Education Canada, Inc., *Toronto*
Pearson Educación de Mexico, S A de C V
Pearson Education—Japan, *Tokyo*
Pearson Education Malaysia, Pte Ltd
Pearson Education, Inc , *Upper Saddle River, New Jersey*

Nomenclature

AC	annual cost
ACWP	actual cost of work performed
AHP	analytic hierarchy process
AOA	activity on arrow
AON	activity on node
AW	annual worth
BAC	budget at completion
B/C	benefit/cost
BCWP	budgeted cost of work performed
BCWS	budgeted cost of work scheduled
CBS	cost breakdown structure
CCB	change control board
CCBM	critical chain buffer management
CDR	critical design review
CE	certainty equivalent, concurrent engineering
C-E	cost-effectiveness
CER	cost estimating relationship
CI	cost index; consistency index; criticality index
CM	configuration management
COO	chief operating officer
CPIF	cost plus incentive fee
CPM	critical path method
CR	capital recovery, consistency ratio
C/SCSC	cost/schedule control systems criteria
CV	cost variance
DOD	Department of Defense
DOE	Department of Energy
DOH	direct overhead costs
DSS	decision support system
EAC	estimate at completion
ECO	engineering change order
ECR	engineering change request
EMV	expected monetary value
EOM	end of month
EOY	end of year
ERP	enterprise resource planning
ETC	estimate to complete
ETMS	early termination monitoring system
EUAC	equivalent uniform annual cost
EV	earned value
EVPI	expected value of perfect information
EVSI	expected value of sample information
FFP	firm fixed price
FMS	flexible manufacturing system
FPIF	fixed price incentive fee
FW	future worth
GAO	General Accounting Office
GDSS	group decision support system
GERT	graphical evaluation and review technique
HR	human resources
IPT	integraded product team
IRR	internal rate of return
IRS	Internal Revenue Service

ISO	International Standards Organization
IT	information technology
LCC	life-cycle cost
LOB	line of balance
LOE	level of effort
LP	linear program
LRC	linear responsibility chart
MACRS	modified accelerated cost recovery system
MARR	minimum acceptable (attractive) rate of return
MAUT	multiattribute utility theory
MBO	management by objectives
MIS	management information system
MIT	Massachusetts Institute of Technology
MPS	master production schedule
MTBF	mean time between failures
MTTR	mean time to repair
NAC	net annual cost
NASA	National Aeronautics and Space Administration
NBC	nuclear, biological, chemical
NPV	net present value
OBS	organizational breakdown structure
O&M	operations and maintenance
PDMS	product data management system
PDR	preliminary design review
PERT	program evaluation and review technique
PMBOK	project management body of knowledge
PMI	Project Management Institute
PMP	project management professional
PO	project office
PT	project team
PV	planned value
PW	present worth
QA	quality assurance
QFD	quality function deployment
RAM	reliability, availability, and maintainability; random access memory
R&D	research and development
RDT&E	research, development, testing, and evaluation
RFP	request for proposal
ROR	rate of return
SI	schedule index
SOW	statement of work
SOYD	sum-of-the-years digits
SV	schedule variance
TQM	total quality management
WBS	work breakdown structure
WP	work package
WR	work remaining

Preface

We all deal with projects in our daily lives. In most cases, organization and management simply amount to constructing a list of tasks and executing them in sequence, but when the information is limited or imprecise and when cause-and-effect relationships are uncertain, a more considered approach is called for. This is especially true when the stakes are high and time is pressing. Getting the job done right the first time is essential. This means doing the upfront work thoroughly, even at the cost of lengthening the initial phases of the project. Shaving expenses in the early stages with the intent of leaving time and money for revisions later might seem like a good idea but could have consequences of painful proportions. Seasoned managers will tell you that it is more cost-effective in the long run to add five extra engineers at the beginning of a project than to have to add 50 toward the end.

The quality revolution in manufacturing has brought this point home. Companies in all areas of technology have come to learn that quality cannot be inspected into a product; it must be built in. Recalling the 1980s, the global competitive battles of that time were won by companies that could achieve cost and quality advantages in existing, well-defined markets. In the 1990s, these battles were won by companies that could build and dominate new markets. Today, the emphasis is partnering and better coordination of the supply chain. Planning is a critical component of this process and is the foundation of project management.

Projects may involve dozens of firms and hundreds of people who need to be managed and coordinated. They need to know what has to be done, who is to do it, when it should be done, how it will be done, and what resources will be used. Proper planning is the first step in communicating these intentions. The problem is made difficult by what can be characterized as an atmosphere of uncertainty, chaos, and conflicting goals. To ensure teamwork, all major participants and stakeholders should be involved at each stage of the process.

How is this achieved efficiently, within budget, and on schedule? The primary objective in writing our first book was to answer this question from the perspective of the project manager. We did this by identifying the components of modern project management and showing how they relate to the basic phases of a project, starting with conceptual design and advanced development, and continuing through detailed design, production, and termination. Taking a practical approach, we drew on our collective experience in the electronics, information services, and aerospace industries. The purpose of

this book is to update the developments in the field over the last 10 years and to expand on some of the concerns that are foremost in the minds of practitioners. In so doing, we have incorporated new material in many of the chapters specifically related to the *Project Management Body of Knowledge—PMBOK* published by the Project Management Institute. This material reflects the tools, techniques, and processes that have gained widespread acceptance by the profession because of their proven value and usefulness.

Over the years, numerous books have been written with similar objectives in mind. We acknowledge their contribution and have endeavored to build on their strengths. As such, we have focused on integrative concepts rather than isolated methodologies. We have relied on simple models to convey ideas and have intentionally avoided detailed mathematical formulations and solution algorithms—aspects of the field better left to other parts of the curriculum. Nevertheless, we do present some models of a more technical nature and provide references for readers who wish to gain a deeper understanding of their use. The availability of powerful, commercial codes brings model solutions within reach of the project team.

To ensure that project participants work toward the same end and hold the same expectations, short- and long-term goals must be identified and communicated continually. The project plan is the vehicle by which this is accomplished and, once approved, becomes the basis for monitoring, controlling, and evaluating progress at each phase of the project's life cycle. To help the project manager in this effort, various software packages have been developed; the most common run interactively on microcomputers and have full functional and report-generating capabilities. In our experience, even the most timid users are able to take advantage of their main features after only a few hours of hands-on instruction.

A second objective in writing this book has been to fill a void between texts aimed at low- to midlevel managers and those aimed at technical personnel with strong analytic skills but little training in or exposure to organizational issues. Those who teach engineering or business students at both the late undergraduate and early graduate levels should find it suitable. In addition, the book is intended to serve as a reference for the practitioner who is new to the field or who would like to gain a surer footing in project management concepts and techniques.

The core material, including most of the underlying theory, can be covered in a one-semester course. At the end of Chapter 1, we outline the book's contents. Chapter 3 deals with economic issues, such as cash flow, time value of money, and depreciation, as they relate to projects. With this material and some supplementary notes, coupled with the evaluation methods and multiple criteria decision-making techniques discussed in Chapters 5 and 6, respectively, it should be possible to teach a combined course in project management and engineering economy. This is the direction in which many undergraduate engineering programs are now headed after many years of industry prodding. Young engineers are often thrust into leadership roles without adequate preparation or training in project management skills.

Writing a textbook is a collaborative effort involving many people whose names do not always appear on the cover. In particular, we thank all those faculty who adopted

the first edition of the book and provided us with their constructive and informative comments over the years. With regard to production, much appreciation goes to Lillian Bluestein for her thorough job in proofreading and editing the draft manuscript. We would also like to thank Chen Gretz-Shmueli for her contribution to the discussion in the human resources section. Finally, we are forever grateful to the phalanx of students who have studied project management at our universities and who have made the painstaking efforts of gathering and writing new material all worthwhile.

AVRAHAM SHTUB
JONATHAN F. BARD
SHLOMO GLOBERSON

About the Authors

Avraham Shtub is the Sharon and Stephen Seiden Professor of Project Management in the School of Industrial Engineering and Management at the Technion–Israel Institute of Technology. He received the Ph.D. degree in management science and industrial engineering from the University of Washington, the M.B.A. degree from Tel Aviv University, and the B.Sc. degree in electrical engineering from the Technion. He is a senior member of the Institute of Industrial Engineers and is certified as a Project Management Professional by the Project Management Institute. Professor Shtub's research focuses on the design and management of manufacturing systems, project management, and learning and forgetting. He is on the editorial boards of IIE Transactions and the International Journal of Production Research, and has previously served on the editorial boards of the Project Management Journal and the International Journal of Project Management.

Jonathan F. Bard is a professor of operations research and industrial engineering in the Mechanical Engineering Department at the University of Texas at Austin. He holds the Industrial Properties Corporation Endowed Faculty Fellowship, and serves as the Associate Director of the Center for the Management of Operations and Logistics. He received the D.Sc. degree in operations research from the George Washington University, the M.S. degree in aeronautics and astronautics from Stanford University, and the B.S. degree in aeronautical engineering from Rensselaer Polytechnic Institute. Professor Bard's research interests are in the design and analysis of manufacturing systems, personnel scheduling, R&D project management, and vehicle routing. Prior to beginning his academic career, he worked as a program manager for the Aerospace Corporation and as a systems engineer for Booz, Allen & Hamilton. He is currently the editor of IIE Transactions on Operations Engineering and serves on the editorial board of several other journals. He is a Fellow of IIE and a Senior Member of IEEE and INFORMS.

Shlomo Globerson is a professor in the School of Business Administration at Tel Aviv University. He received the Ph.D. degree in industrial engineering from the University of California, Berkeley, the M.S. degree in industrial engineering from the Faculty of Industrial Engineering and Management at the Technion–Israel Institute of Technology, and the B.Sc. degree in mechanical engineering from the Technion. His primary research and teaching activities center on project management and operations management. He has published seven books and over 80 articles. Professor Globerson is the former President of the Israeli chapter of the Project Management Institute and currently serves on the advisory board for the Industrial Engineering Handbook. He is also on the editorial boards of the Journal of Operations Management and the International Journal of Project Management.

Contents