

CONSTRUCTION PLANNING AND SCHEDULING



JIMMIE W. HINZE

Library of Congress Cataloging-in-Publication Data

Hinze, Jimmie.

Construction planning and scheduling / Jimmie Hinze.

p. cm.

Includes bibliographical references and index.

ISBN 0-13-541301-X

1. Building--Superintendence. 2. Production scheduling.

I. Title.

TH438.4.H55 1998

690'.068--dc21

97-34200

CIP

Editor: Ed Francis

Production Editor: Mary Harlan

Text Designer and Production Coordinator: Custom Editorial Productions, Inc.

Cover Designer: Lori M. Abel

Cover photo: SuperStock

Production Manager: Pamela D. Bennett

Marketing Manager: Danny Hoyt

This book was set in Minion and Memphis by Custom Editorial Productions, Inc., and was printed and bound by R. R. Donnelley & Sons Company. The cover was printed by Phoenix Color Corp.

© 1998 by Prentice-Hall, Inc.

Upper Saddle River, New Jersey 07458

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

Reprinted with Corrections October, 1999

Printed in the United States of America

10 9 8 7 6 5 4 3 2

ISBN: 0-13-541301-X

Prentice-Hall International (UK) Limited, *London*

Prentice-Hall of Australia Pty. Limited, *Sydney*

Prentice-Hall of Canada, Inc., *Toronto*

Prentice-Hall Hispanoamericana, S. A., *Mexico*

Prentice-Hall of India Private Limited, *New Delhi*

Prentice-Hall of Japan, Inc., *Tokyo*

Prentice-Hall Asia Pte. Ltd., *Singapore*

Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

Contents



INTRODUCTION	1
Bar Charts	2
Shortcomings of Bar Charts	3
Value of Bar Charts	5
Reasons for Planning and Scheduling in Construction	8
CHAPTER 1 DEVELOPING A NETWORK MODEL	10
Steps in Building a Network Model	10
Defining Activities	11
Ordering Activities	13
Drawing the Network Diagram	16
Assigning Durations to Activities	18
Assigning Resources and Costs	19
Calculating Early and Late Start/Finish Times	19
Scheduling Activity Start/Finish Times	20
Final Comments	20
Review Questions	20
CHAPTER 2 DEVELOPING AN ARROW-DIAGRAM NETWORK	21
Activity Relationships	22
The i-j Notation of Activities	25
Dummies	25
Other Activity Relationships	31
Final Comments	34
Review Problems	35

CHAPTER 3 PERFORMING TIME CALCULATIONS WITH ARROW DIAGRAMS	38
Calculating Start and Finish Times	38
Float Values	46
Scheduling Actual Start and Finish Times	51
Early Start	51
Late Start	52
Between Early and Late Start	52
Prior to Early Start	52
After Late Start	52
Understanding Total Float and Free Float	53
Independent Float and Interfering Float	56
Final Comments	59
Review Problems	59
CHAPTER 4 PRECEDENCE DIAGRAMS	66
Precedence (Activity-on-Node) Networks	66
Calculations on a Precedence Network	71
Final Comments	78
Review Problems	79
CHAPTER 5 DETERMINING ACTIVITY DURATIONS	87
Estimating	87
Types of Estimates	87
Conceptual Estimates	87
Detailed Estimates	88
Conducting a Detailed Estimate	88
Estimating Durations	94
Scheduling Issues	97
Factors Influencing Choice of Activity Schedules	98
Weather and the Schedule	99
Uncertainty in Duration Estimates	100
Final Comments	103
Review Questions	103
CHAPTER 6 TIME IN CONTRACT PROVISIONS	105
Time of Completion	106
Notice to Proceed	106

Time Is of the Essence	107
Liquidated Damages—Damages for Late Completion	107
Weather	109
Suspension	109
Use of Completed Portions of the Work	110
Substantial Completion	111
Notice of Delays	111
Avoidable Delays	112
Unavoidable Delays	112
Extension of Time (Avoidable Delays)	113
Extension of Time (Unavoidable Delays)	113
Ownership of Float	115
Units of Time: Working Days or Calendar Days	116
Submittals	119
Cooperation	120
Progress Payments	121
Payment for Materials	123
Final Payment	123
Termination by Contractor	124
Requirements for Project Coordination	124
Progress Schedule	125
Final Comments	130
Review Questions	131
CHAPTER 7 RESOURCE ALLOCATION AND RESOURCE LEVELING	132
The Management of Resources	133
When Resources Are Limited (Resource Allocation)	134
The Manual Solution for Resource Allocation	135
The Brooks Method of Resource Allocation	144
When Project Duration Is Fixed (Resource Leveling)	151
The Manual Solution for Resource Leveling	153
Final Comments	160
Review Problems	161
CHAPTER 8 MONEY AND NETWORK SCHEDULES	176
Cash Flow	177
The Time Value of Money	177
Interest Rates	177

Contractor Cash Disbursements	178
Contract Provisions That Impact Cash Flow	180
Owner Policies and Practices That Impact Cash Flow	182
The Cash-Flow Analysis	182
The Present Worth of Cash Flow	184
The Value of Cash-Flow Analysis	184
Time/Cost Trade-Offs	186
Direct Costs	187
Indirect Job Costs (Job Overhead)	188
Overhead (Company Overhead)	188
Profit	188
Four Different Solutions for Each Network	191
Logically Reducing Project Duration	192
Final Comments	202
Review Problems	203
CHAPTER 9 PROJECT MONITORING AND CONTROL	208
Construction Time	208
Effective Scheduling	210
Monitoring Project Status	211
Difficulties in Assessing Progress	216
Updating the Schedule	216
Controlling the Project	217
As-Built Schedules	220
Final Comments	222
Review Questions	223
CHAPTER 10 COMPUTER SCHEDULING	224
Computer Scheduling Terms	226
Scheduling Software	228
Primavera (P3®)	228
<i>SureTrak Project Manager</i>	229
<i>Computers Associates SuperProject</i>	229
<i>Microsoft Project</i>	230
Creating a Schedule	230
Updating a Schedule	234
Presenting a Schedule	234

Useful Software Features	235
Sorting and Filtering	236
Global Editing	237
Cash-Flow Analysis	237
Resource Leveling	237
Final Comments	237
Review Questions	238
CHAPTER 11 EARNED VALUE: A MEANS FOR INTEGRATING COSTS AND SCHEDULE	239
The Earned Value Concept	240
Difficulties in Integrating Cost and Schedule Systems	241
Final Comments	243
Review Questions and Problems	243
CHAPTER 12 THE IMPACT OF SCHEDULING DECISIONS ON PRODUCTIVITY	247
Working Overtime	247
Increasing the Workforce (Crowding)	249
Increasing the Number of Starting Points	250
Interruption of Work on Multiple Units (Impact of Lost Learning)	250
Learning Applied to Individual Units	253
Learning Applied to Cumulative Units	255
What Happens When Work Is Interrupted?	257
Final Comments	260
Review Questions	260
CHAPTER 13 CPM IN DISPUTE RESOLUTION AND LITIGATION	263
Going to Court	263
Final Comments	269
Review Questions	269
CHAPTER 14 SHORT-INTERVAL SCHEDULES	270
Short-Interval Schedules in the Literature	272
How Contractors Use Short-Interval Schedules	272
Other Short-Interval Schedules	277

Final Comments	282
Review Questions	282
CHAPTER 15 LINEAR SCHEDULING	283
What Is Linear Scheduling?	284
Example 1: Project to Replace a State Park Walkway	288
Velocity Diagram	288
Buffers	289
Generating the Linear Schedule	289
Example 2: Project to Construct 500 Tract Housing Units	292
Final Comments	296
Review Questions	296
CHAPTER 16 PERT: PROGRAM EVALUATION AND REVIEW TECHNIQUE	297
Uncertainty in Activity Duration Estimates	297
Uncertainty in the Duration Estimates of an Activity Chain	301
Uncertainty in the Duration Estimates of Projects	303
Monte Carlo Simulation	304
Final Comments	305
Review Problems	305
REFERENCES	309
ADDITIONAL REFERENCES	311
INDEX	315