



# Construction Planning for Engineers

F. H. (Bud) Griffis

John V. Farr



McGRAW-HILL INTERNATIONAL EDITIONS

Civil Engineering Series

# CONTENTS

---

## PART I Program Planning

---

<b>1</b>	<b>Introduction to Program Planning</b>	<b>3</b>
1.1	Introduction	3
1.2	Definitions	5
1.3	Applications	6
	<i>1.3.1 A Flood Control Program / 1.3.2 An Airport Redevelopment Program / 1.3.3 A Landfill Closure Program</i>	
1.4	Constraints That Affect the Planning Process	16
	<i>1.4.1 Physical Constraints / 1.4.2 Technological Constraints / 1.4.3 Economic Constraints / 1.4.4 Social Constraints / 1.4.5 Ecological Constraints / 1.4.6 Political Constraints</i>	
1.5	Implementing the Program Plan	21
1.6	Updating the Program Plan	21
1.7	Summary	22
<b>2</b>	<b>The Planning Process</b>	<b>24</b>
2.1	Introduction	24
2.2	Problem Formulation	27
	<i>2.2.1 Identify Problems and Needs / 2.2.2 Collect and Analyze Data / 2.2.3 Develop Goals and Objectives / 2.2.4 Identify Hard and Soft Constraints</i>	
2.3	Conduct Analysis	32
	<i>2.3.1 Identify Alternatives / 2.3.2 Analyze Alternatives and Assess Impacts / 2.3.3 Evaluate and Recommend Selected Alternative</i>	
2.4	Implementation	38
	<i>2.4.1 Develop Implementation Plan / 2.4.2 Evaluate and Manage</i>	
2.5	Summary	38
<b>3</b>	<b>Decision Making</b>	<b>42</b>
3.1	Introduction	42
3.2	Quantitative Decision Making under Conditions of Certainty	43
	<i>3.2.1 Introduction / 3.2.2 Weighting and Scoring Techniques / 3.2.3 Mathematical Programming</i>	

3.3	Quantitative Decision Making under Conditions of Uncertainty	57
	<i>3.3.1 Introduction / 3.3.2 Payoff Tables / 3.3.3 Criteria for Making Decisions / 3.3.4 Decision Making with Known States of Nature</i>	
3.4	Other Methods of Decision Analysis	64
3.5	Summary	65

## **PART II Project Planning**

<b>4</b>	<b>Introduction to Project Planning</b>	<b>73</b>
4.1	Introduction	73
	<i>4.1.1 Defining the Project / 4.1.2 Project Delivery Methods / 4.1.3 Procurement of Design and Construction Services</i>	
4.2	Project Planning in the Design Phase	77
	<i>4.2.1 Scheduling and Budgeting in the Design Process</i>	
4.3	Project Planning in the Construction Phase	81
	<i>4.3.1 Understanding the Project / 4.3.2 Select the Activities / 4.3.3 Establish Activity Durations / 4.3.4 How to Account for Weather and Contingencies</i>	
4.4	Summary	88
<b>5</b>	<b>Critical-Path Method</b>	<b>90</b>
5.1	Introduction	90
5.2	Development of the ADM Network	93
5.3	Development of the PDM Network	94
5.4	CPM Calculations	96
	<i>5.4.1 Estimating Activity Durations / 5.4.2 Forward Pass Calculations / 5.4.3 Backward Pass Calculations / 5.4.4 Total Float / 5.4.5 Free Float / 5.4.6 Critical Path</i>	
5.5	Bar Charts for Project Scheduling	103
5.6	Work Breakdown Structure	104
5.7	Activity Coding	104
5.8	Resource Requirements	105
5.9	Project Controls	106
	<i>5.9.1 Progress Measurement / 5.9.2 Evaluation of CPM</i>	
5.10	Summary	110
<b>6</b>	<b>Stochastic Networks</b>	<b>117</b>
6.1	Introduction	117
6.2	Types of Stochastic Networks	118
6.3	Program Evaluation and Review Technique (PERT)	118
	<i>6.3.1 Central Limit Theorem</i>	

6.4	Monte Carlo Simulation of Networks	123
6.4.1	<i>Simulation with Activity Duration as Random Variables /</i>	
6.4.2	<i>Simulation with Activity Costs as Random Variables /</i>	
6.4.3	<i>Simulation with Random Logic</i>	
6.5	Simulation with Network Simulation Software	136
6.6	Summary	136
<b>7</b>	<b>Resource Analysis</b>	<b>146</b>
7.1	Introduction	146
7.1.1	<i>Labor / 7.1.2 Equipment / 7.1.3 Material /</i>	
7.1.4	<i>Subcontractors</i>	
7.2	Types of Resources	148
7.2.1	<i>Driving Resources / 7.2.2 Nondriving Resources</i>	
7.3	Relationships between Driving Resources and Production Rates	150
7.4	Relationship between Resources and Costs	151
7.5	Relationship between Resources and Durations	151
7.6	Develop a Resource Plan	152
7.6.1	<i>Resource Allocation</i>	
7.7	Resource Leveling	154
7.7.1	<i>Basic Leveling Concepts</i>	
7.8	Summary	160

### **PART III Activity Planning**

---

<b>8</b>	<b>Introduction to Activity Planning</b>	<b>171</b>
8.1	Introduction	171
8.2	Definition of Construction Activities	172
8.3	What Is Activity Planning?	174
8.4	Another Categorization of Activities	175
8.4.1	<i>Production-Related Activities / 8.4.2 Procurement</i>	
8.4.3	<i>Administration Activities</i>	
8.5	Randomness of Activity Parameters	180
8.6	A Practical Approach	183
8.7	Management of Construction Activities	183
8.7.1	<i>Production Target Graph / 8.7.2 Forecasting Final</i>	
8.7.2	<i>Activity Durations</i>	
8.8	Summary	186
<b>9</b>	<b>Planning for Equipment-Driven Activities</b>	<b>190</b>
9.1	Introduction	190
9.2	Heuristics	191
9.3	Statistical Studies	193
9.4	Cycle Time Analysis	195

9.5	Queuing Theory	199
	9.5.1 <i>Deterministic Queuing Analysis</i> / 9.5.2 <i>Stochastic Queuing Theory</i>	
9.6	Introduction to Simulation	208
	9.6.1 <i>System Entity Representation</i> / 9.6.2 <i>Commercial Simulation Software</i>	
9.7	Summary	218
<b>10</b>	<b>Planning for Labor-Driven Activities</b>	<b>229</b>
10.1	Introduction	229
10.2	Labor Wages and Labor Costs	231
10.3	Crew Design	234
10.4	Labor Productivity Estimates	239
10.5	Improving Labor Productivity	243
	10.5.1 <i>Learning Curve</i> / 10.5.2 <i>Factors Affecting Labor Productivity</i> / 10.5.3 <i>Improving Labor Productivity</i>	
10.6	Summary	252
<b>Appendix A</b>	<b>Program, Project, and Activity Planning: Putting It All Together</b>	<b>257</b>
A.1	Introduction	257
A.2	Nursing Home Program (Requirement 1)	258
A.3	Nursing Home Project (Requirement 2)	262
A.4	Request for Proposals	263
	A.4.1 <i>Introduction to the RFP</i> / A.4.2 <i>Scope of Work</i> / A.4.3 <i>Proposal Evaluation Factors</i> / A.4.4 <i>Specifications</i>	
A.5	Response to the RFP (Requirement 3)	265
	A.5.1 <i>Background and Experience</i> / A.5.2 <i>Project Schedule</i> / A.5.3 <i>Cost Estimate</i> / A.5.4 <i>Management Plan</i>	
A.6	Presentation	274
	A.6.1 <i>What Goes into the Presentation?</i> / A.6.2 <i>Who Does It?</i> / A.6.3 <i>Presentation Details</i> / A.6.4 <i>Tips for Presenting</i>	
A.7	Summary	278
	Project for Construction Planning for Engineers	280
<b>Appendix B</b>	<b>Economic Analysis of Alternatives</b>	<b>293</b>
B.1	Introduction	293
B.2	Capital Budgeting Decision	293
	B.2.1 <i>Basic Concepts in Capital Budgeting</i>	
B.3	Benefit and Cost Development	295
B.4	Time Value of Money	296
	B.4.1 <i>Interest</i>	
B.5	Investment Measures	305

B.6	Advanced Cash Flow Analysis	308
	<i>B.6.1 Depreciation / B.6.2 Corporate Income Taxes /</i>	
	<i>B.6.3 Inflation and Deflation / B.6.4 Net Cash</i>	
	<i>Flow Schedules</i>	
B.7	Summary	314

<b>Appendix C</b>	<b>Introduction to Probability and Statistics</b>	<b>323</b>
C.1	Introduction	323
C.2	Descriptive Statistics	324
	<i>C.2.1 Measures of Central Tendency / C.2.2 Measures of</i>	
	<i>Variability / C.2.3 Regression / C.2.4 Correlation</i>	
C.3	Probability	329
	<i>C.3.1 Random Variables / C.3.2 Probability Density</i>	
	<i>Functions / C.3.3 Cumulative Distribution Functions /</i>	
	<i>C.3.4 Special Distributions</i>	
C.4	Mathematical Expectation	345
C.5	Summary	347
	<b>Index</b>	<b>353</b>