Contents

Preface xv
Authors xvii

1. **Fundamentals of Project Management** 1
   - Why Projects Fail 4
   - Management by Project 5
   - Integrated Project Implementation 6
   - Critical Factors for Project Success 8
   - Early Systems Engineering 9
   - DODAF Systems Architecture for Project Management 9
   - Project Management Body of Knowledge (PMBOK®) 10
     - Components of Knowledge Areas 11
     - Step-by-Step and Component-by-Component Implementation 13
   - Project Systems Structure 16
     - Problem Identification 16
     - Project Definition 16
     - Project Planning 16
     - Project Organization 16
     - Resource Allocation 17
     - Project Scheduling 17
     - Project Tracking and Reporting 17
     - Project Control 18
     - Project Termination 18
   - Project Systems Implementation Outline 18
     - Planning 19
     - Organizing 19
     - Scheduling (Resource Allocation) 20
     - Control (Tracking, Reporting, and Correction) 20
     - Termination (Close- or Phase-Out) 21
     - Documentation 21
   - Value of Lean Times 21
   - Project Decision Analysis 22
   - Systems Group Decision-Making Models 25
     - Brainstorming 26
     - Delphi Method 26
     - Nominal Group Technique 28
     - Interviews, Surveys, and Questionnaires 29
     - Multivoting 30
   - Hierarchy of Project Control 30

2. Statistics for Project Control 37
Modeling Project Environment 37
Use of Statistics in Project Control 38
Normal Distribution 39
Relationship to Six Sigma 42
Statistical Averages 43
Arithmetic Mean 43
Geometric Mean 44
Harmonic Mean 45
Mode 46
Median 46
Average Percentage Return 46
Data Patterns 49
Averages of Functions 49
Statistical Thinking: Computational Examples 49
Factors of Project Control 52
Examples of Statistics for Project Control 55
Team Formation and Combination 55
Statistics for Production Changeovers 55
General Control Steps 58
Formal and Informal Control 59
Schedule Control 60
Project Tracking and Reporting 61
Performance Control 65
Scope 65
Documentation 65
Requirements 65
Quality Assurance 66
Function 66
Continuous Performance Improvement 66
Cost Control 69
Information Required for Project Control 70
Measurement Scales 71
Data Determination and Collection 72
Data Analysis and Presentation 75
Control Charts 86

3. Project Time Control 93
Critical Path Method 95
CPM Example 97
Forward Pass 97
Backward Pass 99
Determination of Critical Activities 99
Using Forward Pass to Determine Critical Path 102

Subcritical Paths 102
Gantt Chart 104
Variations 105
Activity Crashing and Schedule Compression 107
PERT Network Analysis 112
Estimates and Formulas 113
Modeling Activity Times 114
Beta Distribution 115
Triangular Distribution 118
Uniform Distribution 119
Statistical Analysis of Project Duration 120
Central Limit Theorem 120
Probability Calculation 120
PERT Network Example 121
Precedence Diagramming 123
Reverse Criticality in PDM Networks 131
References 134

4. Project Performance Control 135
Importance of Work Performance Measurement 135
Basic Techniques of Performance Work Sampling 137
Performance Confidence Interval 138
Sample Size Calculations 138
Control Charts for Performance Control 139
Plan for Typical Work Sampling Study 139
Applications of Work Sampling 140
Machine Utilization 140
Allowances for Personal and Unavoidable Delays 141
Collecting Sampling Data 142
Determining Work Standards 142
Learning Curve Analysis for Performance Control 143
Effects of Learning 144
Univariate Learning Curve Models 145
Log-Linear Model 145
Multivariate Learning Curve Model 147
Model Formulation 147
Bivariate Model 148
Comparison to Univariate Model 153
Potential Applications 153
Design of Training Programs 155
Manufacturing Economic Analysis 155
Breakeven Analysis 155
Make or Buy Decisions 155
Manpower Scheduling 156

Production Planning 156
Labor Estimating 156
Budgeting and Resource Allocation 156
Impacts of Multivariate Learning Curves 156
Summary of Cost, Time, and Performance Formulas 158
References 160

5. Project Cost Control 161
Cost Concepts and Definitions 162
Project Cash Flow Analysis 164
Time Value of Money Calculation 165
Effects of Inflation 179
Breakeven Analysis 182
Profit Ratio Analysis 185
Amortization of Capital 188
Project Cost Estimation 194
Budgeting and Capital Allocation 195
Cost Monitoring 202
Project Balance Technique 204
Activity-Based Costing 204
References 210

6. Project Quality Control 211
Quality Management: Step-By-Step Implementation 211
Six Sigma and Quality Management 212
Taguchi Loss Function 214
Identification and Elimination of Sources of Defects 215
Roles and Responsibilities for Six Sigma 216
Statistical Techniques for Six Sigma 217
Control Charts 217
X-Bar and Range Charts 218
Data Collection Strategies 218
Subgroup Sample Size 219
Sampling Frequency 220
Stable and Unstable Processes 220
Calculation of Control Limits 222
Plotting Control Charts for Range and Average Charts 223
Plotting Control Charts for Moving Range and Individual Control Charts 223
Calculations 225
Trend Analysis 227
Process Capability Analysis for Six Sigma 230
Capable Process (C_p) 231
Capability Index (C_{pk}) 232

Possible Applications of Process Capability Index 234
Potential Abuse of C_p and C_{pk} 235
Lean Principles and Applications 235
Kaizen 236
Lean Task Value Rating System 237
Lean Six Sigma in Project Management 239

7. Lean Principles for Project Control 241
Lean and Six Sigma 241
Pull Technique 250
Lean Action Plan 254

8. Six Sigma and Statistical Modeling 257
Six Sigma and Statistics 257
Selecting Proper Statistical Techniques 258
Six Sigma Methodology 260
Six Sigma Spread 261
5 Ms Lead to 7 Ws 263
Hypothesis Testing 279
t Testing 282
Confidence Interval 282
Capability Analysis 283
Gage R&R 284

9. Project Control Case Studies 289
Gage R&R 289
Gage R&R Study: ANOVA Method 293
Capability Studies 296
Analytical Studies 298
Test for Equal Variances 300
Trend Analysis 302
Simple Linear Regression 308
Hypothesis Testing 310
Multivariate Studies 310
Test for Equal Variances: Measurement versus Software 312
General Linear Model 315
ANOVA Table Based on Using SS 315
Residuals 315
ANOVA Table Based on Using SS 316
Residuals 316

10. Management Support for Project Control 319
Leadership 321
SigmSResource Allocation by Management 324

Appendix: Useful Statistical Distributions 327
Discrete Distributions 327
Bernoulli Distribution 327
Beta Binomial Distribution 330
Beta Pascal Distribution 330
Binomial Distribution 330
Discrete Weibull Distribution 330
Geometric Distribution 330
Hypergeometric Distribution 331
Negative Binomial Distribution 331
Poisson Distribution 332
Rectangular (Discrete Uniform) Distribution 332
Continuous Distributions 332
Arcsin Distribution 333
Beta Distribution 333
Cauchy Distribution 333
Chi Distribution 333
Chi-Square Distribution 334
Erlang Distribution 334
Exponential Distribution 334
Extreme-Value Distribution 335
F Distribution 335
Gamma Distribution 336
Half-Normal Distribution 336
Laplace (Double Exponential) Distribution 336
Logistic Distribution 336
Lognormal Distribution 337
Noncentral Chi-Square Distribution 337
Noncentral F Distribution 337
Noncentral t Distribution 338
Normal Distribution 338
Pareto Distribution 339
Rayleigh Distribution 339
t Distribution 339
Triangular Distribution 340
Uniform Distribution 340
Weibull Distribution 340
Distribution Parameters 341
Estimation and Testing 342
Normal Probability Plot 343
Comparison of Poisson Rates 343
Distribution Functions: Parameter Estimation 344
Bernoulli 344
Binomial 344

Discrete uniform 344
Geometric 344
Negative binomial 345
Poisson 345
Beta 345
Chi-square 345
Erlang 345
Exponential 345
F 345
Gamma 346
Log Normal 346
Normal 346
Student's t 347
Triangular 347
Uniform 347
Weibull (for solving simultaneous equations) 347
Chi-square for Distribution Fitting 348
Kolmogorov-Smirnov Test 348
ANOVA 348
Cochran C-test 350
Bartlett Test 350
Hartley's Test 351
Kruskal-Wallis Test 351
Freidman Test 351
Regression 352
Notation 352
Statistics 352
Predictions 354
Nonlinear Regression 355
Ridge Regression 355
Quality Control 356
Subgroup Statistics 356
X Bar Charts 356
Capability Ratio 358
R Charts 358
S Charts 359
C Charts 359
U Charts 359
P Charts 359
NP Charts 360
CuSum Chart for Mean 360
Multivariate Control Charts 361
Time Series Analysis 361
Autocorrelation at Lag *k* 361

Partial Autocorrelation at Lag k 362
Cross Correlation at Lag k 362
Box-Cox 362
Periodogram Using Fast Fourier Transform 363
Categorical Analysis 363
Chi-Square 364
Fisher's Exact Test 364
Lambda 364
Uncertainty Coefficient 365
Somers' D 365
Eta 366
Contingency Coefficient 367
Cramer's V 367
Conditional Gamma 367
Pearson's r 368
Kendall's Tau B 368
Tau C 368
Probability Terminology 368
Basic Probability Principles 368
Random Variable 369
Mean Value $\hat{x}$ or Expected Value μ 369
Discrete Distribution Formulas 370
Bernoulli Distribution 370
Beta Binomial Distribution 370
Beta Pascal Distribution 370
Binomial Distribution 371
Discrete Weibull Distribution 371
Geometric Distribution 371
Hypergeometric Distribution 371
Negative Binomial Distribution 372
Poisson Distribution 372
Rectangular (Discrete Uniform) Distribution 373
Continuous Distribution Formulas 373
Arcsin Distribution 373
Beta Distribution 373
Cauchy Distribution 374
Chi Distribution 374
Chi-Square Distribution 374
Erlang Distribution 375
Exponential Distribution 375
Extreme Value Distribution 375
F Distribution 375
Gamma Distribution 376
Half-Normal Distribution 377
Laplace (Double Exponential) Distribution 377

Logistic Distribution 377
Lognormal Distribution 377
Noncentral Chi-Square Distribution 378
Noncentral F Distribution 378
Noncentral t Distribution 379
Normal Distribution 379
Pareto Distribution 379
Rayleigh Distribution 380
t-Distribution 380
Triangular Distribution 380
Uniform Distribution 381
Weibull Distribution 381
Variate Generation Techniques 382
Generation Algorithms 382

Index 385