Contents

FOREWORD xiii

ABOUT THE AUTHORS xvii

PREFACE xix

ACRONYMS xxiii

1 "LOOKING BACK: REFLECTIONS ON COST ESTIMATING" 1

Reference, 10

2 INTRODUCTION TO COST ESTIMATING 11

2.1 Introduction, 11
2.2 What is Cost Estimating? 11
2.3 What Are the Characteristics of a Good Cost Estimate? 13
2.4 Importance of Cost Estimating in DoD and in Congress. Why Do We Do Cost Estimating? 14
2.4.1 Importance of Cost Estimating to Congress, 16
2.5 An Overview of the DoD Acquisition Process, 17
2.6 Acquisition Categories (ACATs), 23
2.7 Cost Estimating Terminology, 24
Summary, 30
References, 31
Applications and Questions, 31

3 NON-DOD ACQUISITION AND THE COST ESTIMATING PROCESS 32

3.1 Introduction, 32
3.2 Who Practices Cost Estimation? 32

3.3 The Government Accountability Office (GAO) and the 12-Step Process, 33
3.4 Cost Estimating in Other Non-DoD Agencies and Organizations, 38
3.4.1 The Intelligence Community (IC), 38
3.4.2 National Aeronautics and Space Administration (NASA), 38
3.4.3 The Federal Aviation Administration (FAA), 39
3.4.4 Commercial Firms, 39
3.4.5 Cost Estimating Book of Knowledge (CEBOK), 40
3.4.6 Federally Funded Research and Development Centers (FFRDCs), 41
3.4.7 The Institute for Defense Analysis (IDA), 41
3.4.8 The Mitre Corporation, 42
3.4.9 Rand Corporation, 42
3.5 The Cost Estimating Process, 43
3.6 Definition and Planning. Knowing the Purpose of the Estimate, 43
3.6.1 Definition and Planning. Defining the System, 47
3.6.2 Definition and Planning. Establishing the Ground Rules and Assumptions, 48
3.6.3 Definition and Planning. Selecting the Estimating Approach, 49
3.6.4 Definition and Planning. Putting the Team Together, 51
3.7 Data Collection, 52
3.8 Formulation of the Estimate, 52
3.9 Review and Documentation, 53
3.10 Work Breakdown Structure (WBS), 53
3.10.1 Program Work Breakdown Structure, 53
3.10.2 Military-Standard (MIL-STD) 881C, 56
3.11 Cost Element Structure (CES), 56
Summary, 58
References, 59
Applications and Questions, 59

4 DATA SOURCES 61

4.1 Introduction, 61
4.2 Background and Considerations to Data Collection, 61
4.2.1 Cost Data, 63
4.2.2 Technical Data, 63

4.2.3 Programmatic Data, 64
4.2.4 Risk Data, 64
4.3 Cost Reports and Earned Value Management (EVM), 65
4.3.1 Contractor Cost Data Reporting (CCDR), 65
4.3.2 Contract Performance Report (CPR), 66
4.3.3 EVM Example, 70
4.4 Cost Databases, 74
4.4.1 Defense Cost and Resource Center (DCARC), 75
4.4.2 Operating and Support Costs Databases, 75
4.4.3 Defense Acquisition Management Information Retrieval (DAMIR), 76
Summary, 76
Reference, 77
Applications and Questions, 77

5 DATA NORMALIZATION 78

5.1 Introduction, 78
5.2 Background to Data Normalization, 78
5.3 Normalizing for Content, 80
5.4 Normalizing for Quantity, 81
5.5 Normalizing for Inflation, 83
5.6 DoD Appropriations and Background, 87
5.7 Constant Year Dollars (CY$), 88
5.8 Base Year Dollars (BY$), 90
5.9 DoD Inflation Indices, 91
5.10 Then Year Dollars (TY$), 95
5.11 Using the Joint Inflation Calculator (JIC), 97
5.12 Expenditure (Outlay) Profile, 99
Summary, 103
References, 103
Applications and Questions, 103

6 STATISTICS FOR COST ESTIMATORS 105

6.1 Introduction, 105
6.2 Background to Statistics, 105
6.3 Margin of Error, 106
6.4 Taking a Sample, 109
6.5 Measures of Central Tendency, 110
6.6 Dispersion Statistics, 113
6.7 Coefficient of Variation, 117
Summary, 119
References, 119

General Reference, 119
Applications and Questions, 119

7 LINEAR REGRESSION ANALYSIS 121

7.1 Introduction, 121
7.2 Home Buying Example, 121
7.3 Regression Background and Nomenclature, 126
7.4 Evaluating a Regression, 132
7.5 Standard Error (SE), 133
7.6 Coefficient of Variation (CV), 134
7.7 Analysis of Variance (ANOVA), 135
7.8 Coefficient of Determination (R^2), 137
7.9 F-Statistic and t-Statistics, 138
7.10 Regression Hierarchy, 140
7.11 Staying Within the Range of Your Data, 142
7.12 Treatment of Outliers, 143
7.12.1 Handling Outliers with Respect to X (The Independent Variable Data), 143
7.12.2 Handling Outliers with Respect to Y (The Dependent Variable Data), 144
7.13 Residual Analysis, 146
7.14 Assumptions of Ordinary Least Squares (OLS) Regression, 149
Summary, 149
Reference, 150
Applications and Questions, 150

8 MULTI-VARIABLE LINEAR REGRESSION ANALYSIS 152

8.1 Introduction, 152
8.2 Background of Multi-Variable Linear Regression, 152
8.3 Home Prices, 154
8.4 Multi-Collinearity (MC), 158
8.5 Detecting Multi-Collinearity (MC), Method #1: Widely Varying Regression Slope Coefficients, 159
8.6 Detecting Multi-Collinearity, Method #2: Correlation Matrix, 160
8.7 Multi-Collinearity Example #1: Home Prices, 161
8.8 Determining Statistical Relationships between Independent Variables, 163
8.9 Multi-Collinearity Example #2: Weapon Systems, 164
8.10 Conclusions of Multi-Collinearity, 167

8.11 Multi-Variable Regression Guidelines, 168
Summary, 169
Applications and Questions, 170

9 INTRINSICALLY LINEAR REGRESSION 172

9.1 Introduction, 172
9.2 Background of Intrinsically Linear Regression, 172
9.3 The Multiplicative Model, 173
9.4 Data Transformation, 174
9.5 Interpreting the Regression Results, 178
Summary, 178
Reference, 179
Applications and Questions, 179

10 LEARNING CURVES: UNIT THEORY 180

10.1 Introduction, 180
10.2 Learning Curve, Scenario #1, 180
10.3 Cumulative Average Theory Overview, 182
10.4 Unit Theory Overview, 182
10.5 Unit Theory, 185
10.6 Estimating Lot Costs, 188
10.7 Fitting a Curve Using Lot Data, 191
10.7.1 Lot Midpoint, 192
10.7.2 Average Unit Cost (AUC), 194
10.8 Unit Theory, Final Example (Example 10.5), 197
10.9 Alternative LMP and Lot Cost Calculations, 200
Summary, 202
References, 202
Applications and Questions, 202

11 LEARNING CURVES: CUMULATIVE AVERAGE THEORY 204

11.1 Introduction, 204
11.2 Background of Cumulative Average Theory (CAT), 204
11.3 Cumulative Average Theory, 206
11.4 Estimating Lot Costs, 210
11.5 Cumulative Average Theory, Final Example, 210
11.6 Unit Theory vs. Cumulative Average Theory, 214
11.6.1 Learning Curve Selection, 215
Summary, 216
Applications and Questions, 216

12 Learning Curves: Production Breaks/Lost Learning 218

12.1 Introduction, 218
12.2 The Lost Learning Process, 219
12.3 Production Break Scenario, 219
12.4 The Anderlohr Method, 220
12.5 Production Breaks Example, 221
12.6 The Retrograde Method, Example 12.1 (Part 2), 224
Summary, 229
References, 229
Applications and Questions, 230

13 Wrap Rates and Step-Down Functions 231

13.1 Introduction, 231
13.2 Wrap Rate Overview, 231
13.3 Wrap Rate Components, 232
13.3.1 Direct Labor Rate, 233
13.3.2 Overhead Rate, 233
13.3.3 Other Costs, 234
13.4 Wrap Rate, Final Example (Example 13.2), 235
13.5 Summary of Wrap Rates, 236
13.6 Introduction to Step-Down Functions, 236
13.7 Step-Down Function Theory, 237
13.8 Step-Down Function Example 13.1, 238
13.9 Summary of Step-Down Functions, 240
Reference, 240
Applications and Questions, 240

14 Cost Factors and the Analogy Technique 242

14.1 Introduction, 242
14.2 Cost Factors Scenario, 242
14.3 Cost Factors, 243
14.4 Which Factor to Use? 246
14.5 Cost Factors Handbooks, 246
14.6 Unified Facilities Criteria (UFC), 247
14.7 Summary of Cost Factors, 248
14.8 Introduction to the Analogy Technique, 248
14.9 Background of Analogy, 249
14.10 Methodology, 250
14.11 Example 14.1, Part 1: The Historical WBS, 250
14.12 Example 14.1, Part 2: The New WBS, 253

14.13 Summary of the Analogy Technique, 255
Reference, 256
Applications and Questions, 256

15 SOFTWARE COST ESTIMATION 257

15.1 Introduction, 257
15.2 Background on Software Cost Estimation, 257
15.3 What is Software? 258
15.4 The WBS Elements in a typical Software Cost Estimating Task, 259
15.5 Software Costing Characteristics and Concerns, 260
15.6 Measuring Software Size: Source Lines of Code (SLOC) and Function Points (FP), 261
15.6.1 Source Lines of Code: (SLOC), 261
15.6.2 Function Point (FP) Analysis, 263
15.7 The Software Cost Estimating Process, 264
15.8 Problems with Software Cost Estimating: Cost Growth, 265
15.9 Commercial Software Availability, 267
15.9.1 COTS in the Software Environment, 268
15.10 Post Development Software Maintenance Costs, 268
Summary, 269
References, 269

16 COST BENEFIT ANALYSIS AND RISK AND UNCERTAINTY 270

16.1 Introduction, 270
16.2 Cost Benefit Analysis (CBA) and Net Present Value (NPV) Overview, 270
16.3 Time Value of Money, 273
16.4 Example 16.1. Net Present Value, 277
16.5 Risk and Uncertainty Overview, 281
16.6 Considerations for Handling Risk and Uncertainty, 283
16.7 How do the Uncertainties Affect our Estimate? 284
16.8 Cumulative Cost and Monte Carlo Simulation, 287
16.9 Suggested Resources on Risk and Uncertainty Analysis, 289
Summary, 290
References, 290
Applications and Questions, 290

17 EPILOGUE: THE FIELD OF COST ESTIMATING AND ANALYSIS 291

ANSWERS TO QUESTIONS 295

INDEX 309