# Table of Contents

List of Figures ................................................................. xiii
Preface ................................................................................ xxiii
Acknowledgments ................................................................... xxv

**SECTION 1 EARNED VALUE PROJECT MANAGEMENT AND ORGANIZATION** ................................................................. 29

**Chapter 1 Project Management Using Earned Value** .................. 31
What is a Project? ................................................................. 31
Managing Projects ............................................................... 32
Background ........................................................................... 33
The Performance-Oriented Approach ........................................ 34
Summary Implementation Concerns ......................................... 36
Factors Affecting System Implementation Detail ......................... 37
Earned Value Management System Recognition ....................... 38
The Earned Value Management Process .................................... 38
The Process Steps ............................................................... 38
Conclusion ........................................................................... 42
Chapter 1 Review Questions .................................................. 43

**Chapter 2 Definition of Scope, Work Breakdown Structure (WBS) and WBS Dictionary** .................. 45
Defining Project Objectives ................................................... 46
The Work Breakdown Structure (WBS) .................................... 47
Considerations in Developing a WBS ....................................... 48
WBS Examples ..................................................................... 48
WBS Dictionary .................................................................. 53
Other Considerations in WBS Development ................................ 54
The Contract Work Breakdown Structure (CWBS) ....................... 57
Scope Verification .................................................................. 57
Conclusion ........................................................................... 58
Chapter 2 Review Questions .................................................. 59
Case Study 2.1 Work Breakdown Structure Part 1 ......................... 61
Case Study 2.2 Work Breakdown Structure Part 2 ......................... 67
Case Study 2.3 WBS Element Description ................................. 71

**Chapter 3 Managing Project Risks** ........................................ 77
Introduction to Managing Project Risks ..................................... 77
The Process Flow Diagram .................................................... 79
Relationship of Risk Management to the Earned Value Management System .................................................. 85
   Development of Estimates .................................................. 85
   Quantitative Schedule Risk Analysis .................................... 85
   Budgets ........................................................................... 85
   Management Reserve ....................................................... 85
   Variance Analysis ........................................................... 85
   Estimates at Completion .................................................... 85
Conclusion ........................................................................... 86
Chapter 3 Review Questions .................................................. 87
Case Study 3.1 Using the Risk Register ....................................... 89
Chapter 4  Relating Organizations, Responsibility, and Work Scope  
  Organizational Structures  ............................................................................. 92  
  Responsibility Assignment Matrix (RAM)  .................................................. 95  
  Control Account Establishment .................................................................... 97  
  Conclusion ......................................................................................................... 100  
  Chapter 4 Review Questions ......................................................................... 101  
  Case Study 4.1  Control Account Definition Part 1 ......................................... 103  
  Case Study 4.2  Control Account Definition Part 2 ......................................... 109  

Chapter 5  Work Teams  ....................................................................................... 111  
  The Work Team ................................................................................................. 111  
  Advantages of Work Teams ............................................................................. 113  
  The Work Team Lead ....................................................................................... 119  
  Conclusion ......................................................................................................... 119  
  Chapter 5 Review Questions ......................................................................... 120  
  Case Study 5.1  Organization Chart and Responsibility Assignment Matrix .... 121  
  Case Study Section 1 Quiz ............................................................................. 127  
  Conclusion ......................................................................................................... 133  

Chapter 6  What is Scheduling? Schedule Types  ............................................. 137  
  Project Scheduling ............................................................................................ 137  
  What is a Schedule and Why Use One? ........................................................... 139  
  Data Requirements ........................................................................................... 140  
  Data Processing ................................................................................................. 140  
  Using Results ..................................................................................................... 141  
  Schedule Types ................................................................................................. 141  
    Gantt Charts .................................................................................................... 141  
    Milestone Chart ............................................................................................... 142  
    Bar Chart ......................................................................................................... 143  
    Combination Chart ........................................................................................ 143  
    Modified Gantt/Milestone Chart .................................................................... 143  
    Flow Process Chart ........................................................................................ 144  
    Set Back Chart ................................................................................................ 144  
    Line of Balance ............................................................................................... 144  
    Network Diagrams .......................................................................................... 145  
  Conclusion ......................................................................................................... 146  
  Chapter 6 Review Questions ......................................................................... 147  
  Case Study 6.1  Developing a Personal Schedule ........................................... 149  

Chapter 7  Introduction to Network Logic Development  ................................... 153  
  Precedence Diagramming Method .................................................................. 153  
  Activity Relationships ....................................................................................... 155  
  Representations of Logic in Time-Phased Formats ......................................... 157  
  Conclusion ......................................................................................................... 159  
  Chapter 7 Review Questions ......................................................................... 160  
  Case Study 7.1  Constructing a Network Diagram ........................................... 161  

Chapter 8  Critical Path Method Fundamentals ................................................. 163  
  The Critical Path Method .................................................................................. 165  
  Critical Path Example ....................................................................................... 165  
  Network Calculations ...................................................................................... 166
<table>
<thead>
<tr>
<th>Chapter 10 Considerations for Developing a Useful, Quality Schedule</th>
<th>203</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Development Techniques: Top-Down</td>
<td>205</td>
</tr>
<tr>
<td>Network Development Techniques: Bottom-Up</td>
<td>206</td>
</tr>
<tr>
<td>Network Development Techniques: IMP/IMS</td>
<td>206</td>
</tr>
<tr>
<td>Concerns in the Schedule Development Process</td>
<td>208</td>
</tr>
<tr>
<td>Using Hammocks, Summary Activities and Grouping for Concise Reporting</td>
<td>209</td>
</tr>
<tr>
<td>Templates</td>
<td>209</td>
</tr>
<tr>
<td>Lags, Leads and Date Constraints</td>
<td>212</td>
</tr>
<tr>
<td>Schedule Margin</td>
<td>216</td>
</tr>
<tr>
<td>Buffer Activity Method</td>
<td>216</td>
</tr>
<tr>
<td>Baseline Finish Variance Method</td>
<td>217</td>
</tr>
<tr>
<td>Resource Application</td>
<td>217</td>
</tr>
<tr>
<td>Schedule Approaches</td>
<td>217</td>
</tr>
<tr>
<td>Schedule Visibility Versus Risk</td>
<td>219</td>
</tr>
<tr>
<td>Determining Detail</td>
<td>219</td>
</tr>
<tr>
<td>Creating and Maintaining Quality Schedules</td>
<td>220</td>
</tr>
<tr>
<td>Fourteen Point Schedule Health Check</td>
<td>221</td>
</tr>
<tr>
<td>Fourteen Point Schedule Health Check – Correlation with GASP</td>
<td>226</td>
</tr>
<tr>
<td>Conclusion</td>
<td>227</td>
</tr>
<tr>
<td>Chapter 10 Review Questions</td>
<td>229</td>
</tr>
<tr>
<td>Case Study 10.1 Build a Network Schedule</td>
<td>231</td>
</tr>
</tbody>
</table>

| Chapter 11 Crashing the Network                               | 235 |
| The “Crashing” Procedure                                      | 237 |
| An Example of Network Crashing                                 | 237 |
| Other Schedule Acceleration Techniques                        | 244 |
| Conclusion                                                    | 245 |
| Chapter 11 Review Questions                                   | 246 |
# Table of Contents

**Chapter 12 Setting a Traceable Schedule Baseline** .................................................. 249  
Schedule Traceability .................................................................................. 251  
A Solution ................................................................................................. 252  
Defining the Schedule Baseline ................................................................. 253  
Schedule Baseline Establishment ............................................................... 254  
Realism and Schedule Detail ................................................................... 256  
Timing of Schedule Baseline Establishment ........................................... 257  
Schedule Baseline Revisions .................................................................... 258  
The Baseline Schedule Versus the Current Schedule .............................. 259  
Conclusion .................................................................................. .......................... 259  
Chapter 12 Review Questions .................................................................... 261  
Case Study 12.1 Vertical and Horizontal Schedule Traceability ................. 263

**Chapter 13 Updating the Schedule** ................................................................. 267  
Successful Schedule Update Process ......................................................... 271  
Additional Statusing Considerations ......................................................... 272  
Methods for Addressing Out-Of-Sequence Logic Status ......................... 272  
- Retained Logic ...................................................................................... 272  
- Progress Override ................................................................................. 275  
- Impact on Total Float ............................................................................ 276  
Conclusion .................................................................................. .......................... 278  
Chapter 13 Review Questions .................................................................... 279  
Case Study 13.1 Analyzing the Schedule .................................................. 281

**Chapter 14 Schedule Changes** ...................................................................... 283  
Duration Changes ...................................................................................... 285  
Measuring Schedule Status ...................................................................... 286  
Defining Significant Changes ................................................................... 286  
Recording the Changes ............................................................................ 286  
Work-Around Plans .................................................................................. 287  
Baseline Changes ..................................................................................... 288  
Conclusion .................................................................................. .......................... 288  
Chapter 14 Review Questions .................................................................... 289  
Case Study 14.1 Analyzing Schedule Changes .......................................... 291

**Chapter 15 Resolving Negative Float** .............................................................. 295  
Float Analysis at Status Update ................................................................. 295  
Isolating the Cause of Float Deterioration ................................................. 298  
Impact of the Delay .................................................................................. 299  
Resolution Alternatives for Negative Float .............................................. 300  
Float Analysis by Project Team ................................................................. 302  
Conclusion .................................................................................. .......................... 303  
Chapter 15 Review Questions .................................................................... 304  
Case Study 15.1 Resolving Negative Float ................................................ 305

**Chapter 16 Special Networking Considerations** ............................................. 307  
Directed Dates ......................................................................................... 307  
Secondary Float ....................................................................................... 316  
Parallel SS/FF Relationships .................................................................... 318  
Level of Effort ......................................................................................... 319  
Calendar Considerations ......................................................................... 321
# Table of Contents

## Chapter 17 Schedule Risk Assessment
- Reasons for Risk Analysis .......................... 328
- Risk Definition and Use of a Risk Assessment ........ 329
- The CPM Approach to Schedule Risk ................... 330
- Probabilistic Approach to Schedule Risk .............. 330
- Example: Building Foundation Activity .................. 330
- Example: CPM Path Duration ............................ 331
- Risk Analysis of Path Duration .......................... 332
- Cumulative Likelihood Curves (S-Curves) ............... 333
- Validity of CPM Estimates .............................. 335
- Highest Risk Path ....................................... 335
- Schedule Risk at Path Convergence ........................ 336
- Schedule Bias .................................................. 336
- Merge Bias at Path Convergence ......................... 336
- Directed Dates ............................................... 337
- Reducing Durations to Fit the Schedule .................. 338
- Fast Track Impacts ............................................. 338
- Late Start Scheduling ......................................... 338
- Early Start Scheduling ........................................ 339
- Risk Analysis Pitfalls ........................................ 339
- Risk Implementation .......................................... 340
- Schedule Risk Analysis Output ............................ 341
- Cost Risk Analysis Output ................................. 341
- Other Scheduling Issues ...................................... 341
- Risk Assessment Tools ..................................... 342
  - PERT ......................................................... 342
  - Monte Carlo Approach ..................................... 345
- Cost Effective Implementation ............................. 345
- Conclusion ....................................................... 345
- Chapter 17 Review Questions .............................. 347

## Case Study 17.1 Making Activity Duration Distributions .................. 349

## Case Study 17.2 Combining Distributions Along a Path .................. 351

## Case Study 17.3 Schedule EAC and Path Convergence .................. 357

## Chapter 18 Scheduling in a Performance Measurement Environment
- System Description ......................................... 363
- Schedule Traceability ........................................ 363
- Reconciliation to Time-Phased Budgets .................... 365
- Reconciliation of Progress and Performance ................ 365
- Contract Requirements ...................................... 366
- Special Requirements ....................................... 368
- Conclusion ....................................................... 369
- Chapter 18 Review Questions .............................. 370

## Case Study 18.1 Schedule Traceability .................................. 371

## Case Study Section 2 Quiz ........................................ 375
<table>
<thead>
<tr>
<th>Chapter 19 The Estimating Process</th>
<th>387</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of the Estimate</td>
<td>389</td>
</tr>
<tr>
<td>Impacts of Poor Estimating</td>
<td>389</td>
</tr>
<tr>
<td>Prerequisites for Estimate Design</td>
<td>390</td>
</tr>
<tr>
<td>Guidelines</td>
<td>390</td>
</tr>
<tr>
<td>Work Breakdown Structure (WBS)</td>
<td>391</td>
</tr>
<tr>
<td>Templates</td>
<td>391</td>
</tr>
<tr>
<td>WBS Dictionary and Code of Accounts</td>
<td>392</td>
</tr>
<tr>
<td>Estimate Formats/Templates</td>
<td>392</td>
</tr>
<tr>
<td>Conclusion</td>
<td>393</td>
</tr>
<tr>
<td>Chapter 19 Review Questions</td>
<td>394</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 20 Types of Estimates</th>
<th>395</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Estimates</td>
<td>397</td>
</tr>
<tr>
<td>Preliminary Estimates</td>
<td>397</td>
</tr>
<tr>
<td>Detailed Estimates</td>
<td>398</td>
</tr>
<tr>
<td>Definitive Estimate</td>
<td>398</td>
</tr>
<tr>
<td>Impact of &quot;Fast Track&quot; Projects on Estimating</td>
<td>399</td>
</tr>
<tr>
<td>Conclusion</td>
<td>399</td>
</tr>
<tr>
<td>Chapter 20 Review Questions</td>
<td>400</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 21 Estimate Development</th>
<th>401</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Estimating Process</td>
<td>401</td>
</tr>
<tr>
<td>Estimating Methods</td>
<td>406</td>
</tr>
<tr>
<td>Inputs for Estimate Development</td>
<td>406</td>
</tr>
<tr>
<td>Sources of Estimate Inputs</td>
<td>407</td>
</tr>
<tr>
<td>The Use of Defaults in Estimate Preparation</td>
<td>407</td>
</tr>
<tr>
<td>Estimating Guidelines</td>
<td>408</td>
</tr>
<tr>
<td>Level of Estimate Detail</td>
<td>410</td>
</tr>
<tr>
<td>Calculation of Indirect Costs</td>
<td>411</td>
</tr>
<tr>
<td>Developing a Cost Flow</td>
<td>411</td>
</tr>
<tr>
<td>Use of Other Escalation Factors</td>
<td>414</td>
</tr>
<tr>
<td>Estimating Operating and Manufacturing Costs</td>
<td>415</td>
</tr>
<tr>
<td>Software Estimating</td>
<td>416</td>
</tr>
<tr>
<td>Conclusion</td>
<td>417</td>
</tr>
<tr>
<td>Chapter 21 Review Questions</td>
<td>418</td>
</tr>
<tr>
<td>Case Study 21.1 Developing an Estimate</td>
<td>419</td>
</tr>
<tr>
<td>Case Study 21.2 Estimate Modification</td>
<td>421</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 22 Learning Curves</th>
<th>425</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Learning Curve</td>
<td>427</td>
</tr>
<tr>
<td>Cumulative Average Learning Curve</td>
<td>427</td>
</tr>
<tr>
<td>The Difference between Unit Linear and Cumulative Average Linear</td>
<td>427</td>
</tr>
<tr>
<td>Determining the Learning Curve to Use</td>
<td>428</td>
</tr>
<tr>
<td>Typical Learning Curve Values</td>
<td>429</td>
</tr>
<tr>
<td>Impacts to Learning Curves</td>
<td>429</td>
</tr>
<tr>
<td>Conclusion</td>
<td>430</td>
</tr>
<tr>
<td>Chapter 22 Review Questions</td>
<td>431</td>
</tr>
<tr>
<td>Case Study 22.1 Estimating Cost Savings</td>
<td>433</td>
</tr>
</tbody>
</table>
### Table of Contents

#### Chapter 23 Cost Risk Assessment
- Risk Model Definition ............................................. 435
- Risk Analysis Sampling Techniques .............................. 437
- Probability Distributions ........................................... 437
- Risk Assessment Outputs ......................................... 438
- Risk Assessment Output Statistics ............................... 439
- Conducting a Risk Assessment ................................ 442
- Implementation Examples ....................................... 443
- Conclusion ............................................................ 444

#### Chapter 24 Estimate Review
- External Reviews .................................................... 447
- Other Factors in Estimate Reviews ............................ 448
- Team Reviews ....................................................... 448
- Conclusion ............................................................ 449
- Chapter 24 Review Questions ................................. 450

#### Case Study 24.1 Assessing the Estimate .................. 451

#### Chapter 25 Tracking the Estimate
- Estimate Traceability: Tracking the Estimate .............. 453
- Conclusion ............................................................ 459
- Chapter 25 Review Questions ................................. 460

#### Case Study 25.1 Estimate History ........................... 461

#### Chapter 26 Automating the Estimating Function
- Software Evaluation Considerations ....................... 468
- Implementation Concerns .................................... 469
- Conclusion ............................................................ 469
- Chapter 26 Review Questions ................................. 470

#### Case Study Section 3 Quiz ................................. 471

**SECTION 4 EARNED VALUE** ........................................... 477

#### Chapter 27 Earned Value
- The Concept ......................................................... 481
- The Earned Value Process ..................................... 484
- The Value of Earned Value ................................... 485
- Conclusion ............................................................ 485
- Chapter 27 Review Questions ................................. 486

#### Case Study 27.1 The Importance of Earned Value .... 487

#### Chapter 28 The Brick Wall
- The Brick Wall Example ........................................ 489
- Earned Value Brick Wall ....................................... 491
- Conclusion ............................................................ 495
- Chapter 28 Review Questions ................................. 496

#### Case Study 28.1 The Brick Wall ............................ 497

#### Chapter 29 Measuring Accomplishment
- Work Packages .................................................... 499
- Typical Work Packages ....................................... 501
- Discrete Effort ..................................................... 501
<table>
<thead>
<tr>
<th>Chapter 33 Variance Analysis and Corrective Action</th>
<th>573</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance Analysis</td>
<td>573</td>
</tr>
<tr>
<td>Variance Thresholds</td>
<td>574</td>
</tr>
<tr>
<td>Variance Analysis Reports</td>
<td>577</td>
</tr>
<tr>
<td>Heading Information/Earned Value Data</td>
<td>577</td>
</tr>
<tr>
<td>Problem Analysis</td>
<td>578</td>
</tr>
<tr>
<td>Impact</td>
<td>579</td>
</tr>
<tr>
<td>Corrective Action Plan</td>
<td>579</td>
</tr>
<tr>
<td>Estimate at Completion Justification</td>
<td>580</td>
</tr>
<tr>
<td>Approvals</td>
<td>580</td>
</tr>
<tr>
<td>Conclusion</td>
<td>580</td>
</tr>
<tr>
<td>Chapter 33 Review Questions</td>
<td>581</td>
</tr>
<tr>
<td>Case Study 33.1 Calculation of Cost and Schedule Variances</td>
<td>583</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 34 Baseline Revisions and Change Control</th>
<th>585</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change Control</td>
<td>585</td>
</tr>
<tr>
<td>Types and Causes of Changes</td>
<td>585</td>
</tr>
<tr>
<td>Elements of a Change Control Program</td>
<td>587</td>
</tr>
<tr>
<td>How to Control Changes</td>
<td>587</td>
</tr>
<tr>
<td>Change Control and the Baseline</td>
<td>588</td>
</tr>
<tr>
<td>Baseline Changes at the Control Account Level</td>
<td>589</td>
</tr>
<tr>
<td>Incorporating Changes into the PMB</td>
<td>590</td>
</tr>
<tr>
<td>Detailed Tracking of Changes</td>
<td>590</td>
</tr>
<tr>
<td>Internal Replanning</td>
<td>592</td>
</tr>
<tr>
<td>Rubber Baseline</td>
<td>594</td>
</tr>
<tr>
<td>Conclusion</td>
<td>594</td>
</tr>
<tr>
<td>Chapter 34 Review Questions</td>
<td>596</td>
</tr>
<tr>
<td>Case Study 34.1 Contract Budget Base Log</td>
<td>597</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 35 Subcontract Management</th>
<th>603</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of Subcontracts</td>
<td>603</td>
</tr>
<tr>
<td>Subcontract Flowdown Requirements</td>
<td>604</td>
</tr>
<tr>
<td>Subcontract Requests for Proposals</td>
<td>605</td>
</tr>
<tr>
<td>Subcontract Type</td>
<td>606</td>
</tr>
<tr>
<td>Integrating the Subcontractor WBS</td>
<td>607</td>
</tr>
<tr>
<td>Integrating the Schedule</td>
<td>608</td>
</tr>
<tr>
<td>Post Award Baseline Establishment</td>
<td>608</td>
</tr>
<tr>
<td>Establishing the Schedule Baseline</td>
<td>608</td>
</tr>
<tr>
<td>Establishing the Budget Baseline</td>
<td>609</td>
</tr>
<tr>
<td>Prime Contractor Considerations for Subcontracts without EVMSG Requirements</td>
<td>612</td>
</tr>
<tr>
<td>Incentive or Cost Plus</td>
<td>612</td>
</tr>
<tr>
<td>Firm Fixed Price (FFP)</td>
<td>612</td>
</tr>
<tr>
<td>Time and Materials (T&amp;M)</td>
<td>613</td>
</tr>
<tr>
<td>Technical Services</td>
<td>613</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Additional Considerations When Planning Subcontract Budgets</td>
</tr>
<tr>
<td></td>
<td>Factoring Subcontract Budgets</td>
</tr>
<tr>
<td></td>
<td>Special Organizational Situations</td>
</tr>
<tr>
<td></td>
<td>Inter-Divisional Work Authorization (IDWA)</td>
</tr>
<tr>
<td></td>
<td>Badgeless Organizations</td>
</tr>
<tr>
<td></td>
<td>Revisions</td>
</tr>
<tr>
<td></td>
<td>Directed Changes</td>
</tr>
<tr>
<td></td>
<td>Internal Replanning</td>
</tr>
<tr>
<td></td>
<td>Formal Reprogramming</td>
</tr>
<tr>
<td></td>
<td>Subcontract Data Analysis</td>
</tr>
<tr>
<td></td>
<td>Subcontract EVMS Reviews and Surveillance</td>
</tr>
<tr>
<td></td>
<td>EVMS Guideline Compliance with Validation</td>
</tr>
<tr>
<td></td>
<td>EVMS Guideline Compliance without Validation</td>
</tr>
<tr>
<td></td>
<td>EV Reporting without EVMS Guideline Compliance</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
</tr>
<tr>
<td></td>
<td>Chapter 35 Review Questions</td>
</tr>
<tr>
<td></td>
<td>Case Study Section 4 Quiz</td>
</tr>
<tr>
<td></td>
<td><strong>Section 5 Implementation of the Project Management Process</strong></td>
</tr>
<tr>
<td></td>
<td>Chapter 36 Implementation of the Project Management Process</td>
</tr>
<tr>
<td></td>
<td>Background</td>
</tr>
<tr>
<td></td>
<td>System Design</td>
</tr>
<tr>
<td></td>
<td>System Description</td>
</tr>
<tr>
<td></td>
<td>The Creation of Storyboards</td>
</tr>
<tr>
<td></td>
<td>Identification of Areas Needing Improvement</td>
</tr>
<tr>
<td></td>
<td>Hardware and Software Selection</td>
</tr>
<tr>
<td></td>
<td>Development of Procedures and Training Material</td>
</tr>
<tr>
<td></td>
<td>System Start-up</td>
</tr>
<tr>
<td></td>
<td>Changes to System Operation</td>
</tr>
<tr>
<td></td>
<td>Routine Operation</td>
</tr>
<tr>
<td></td>
<td>Implementation Schedules</td>
</tr>
<tr>
<td></td>
<td>Tailoring the System for Project Unique Requirements</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
</tr>
<tr>
<td></td>
<td>Chapter 36 Review Questions</td>
</tr>
<tr>
<td></td>
<td><strong>Section 6 Conclusion, Solutions, and References</strong></td>
</tr>
<tr>
<td></td>
<td>Solutions</td>
</tr>
<tr>
<td></td>
<td>Earned Value Analysis Formulas</td>
</tr>
<tr>
<td></td>
<td>Abbreviations</td>
</tr>
<tr>
<td></td>
<td>Glossary</td>
</tr>
<tr>
<td></td>
<td>Bibliography</td>
</tr>
<tr>
<td></td>
<td>Index</td>
</tr>
<tr>
<td></td>
<td>About the Author</td>
</tr>
</tbody>
</table>
List of Figures

Chapter 1 Project Management Using Earned Value

Figure 1-1 Shocking Surprises ........................................... 34
Figure 1-2 Budget Plan vs. Actual Cost ................................. 35
Figure 1-3 Overrun or Ahead of Schedule? ......................... 35
Figure 1-4 Underrun or Behind Schedule? ......................... 35
Figure 1-5 Significant Overrun or Accelerated Schedule? .......... 35
Figure 1-6 A Performance Oriented Approach Provides Better Visibility ......................... 36
Figure 1-7 Cost and Schedule Impacts ................................. 36
Figure 1-8 Earned Value Project Management: The Process .......... 39

Chapter 2 Definition of Scope, Work Breakdown Structure (WBS) and WBS Dictionary

Figure 2-1 Earned Value Project Management: The Process ........ 46
Figure 2-2 600 Megawatt WBS .......................................... 48
Figure 2-3 Boiler Plant Equipment WBS .............................. 49
Figure 2-4 Coal Handling System WBS ............................... 49
Figure 2-5 Storage and Preparation WBS ............................. 49
Figure 2-6 Sewer Treatment Plant WBS .............................. 50
Figure 2-7 Floor Covering WBS ........................................ 50
Figure 2-8 Consulting WBS ............................................ 51
Figure 2-9 DOE Project Summary WBS .............................. 51
Figure 2-10 Sample Project WBS Software Development Project ... 52
Figure 2-11 Sample Project WBS Software Development Project details 52
Figure 2-12 Sample Project WBS ....................................... 53
Figure 2-13 CWBS Dictionary and Contract ......................... 54
Figure 2-14 Element of Cost Orientation ......................... 55
Figure 2-15 Phase Orientation ....................................... 55
Figure 2-16 Engineering/Design WBS .............................. 56
Figure 2-17 Engineering/Design WBS .............................. 56
Figure 2-18 Product - User Mapping ............................... 57

Chapter 3 Managing Project Risks

Figure 3-1 Earned Value Project Management: The Process ........ 78
Figure 3-2 Managing Project Risks: The Process ................ 79
Figure 3-3 Sample Risk Register ..................................... 81
Figure 3-4 Widget Project Risk Register ..................... 83

Chapter 4 Relating Organizations, Responsibility, and Work Scope

Figure 4-1 Earned Value Project Management: The Process ........ 92
Figure 4-2 Functional Organization .................................. 93
Figure 4-3 Project Organization ....................................... 93
Figure 4-4 Weak Matrix ........................................ 93
Figure 4-5 Strong Matrix .......................................... 93
Figure 4-6 Balanced Matrix ......................................... 94
Figure 4-7 Composite Organization ................................. 95
Figure 4-8 Responsibility Assignment Matrix (RAM) .............. 96
Figure 4-9 Responsibility Assignment Matrix and Control Account Structure 97
Figure 4-10 Control Account Example 1 ............................ 98
Figure 4-11 Control Account Example 2 ............................ 98
Figure 4-12 Control Account Example 3 ............................ 99
Figure 4-13 Control Account Example 4 ............................ 99
Chapter 5  Work Teams

- Figure 5-1  Earned Value Project Management: The Process ........................................... 112
- Figure 5-2  Typical Responsibility Matrix - Functional Alignment ..................................... 115
- Figure 5-3  Potential Work Team Alignment - 1 ................................................................. 115
- Figure 5-4  Potential Work Team Alignment - 2 ................................................................. 116
- Figure 5-5  Potential Work Team Alignment - 3 ................................................................. 117
- Figure 5-6  Work Team Application - Example 1 ............................................................... 117
- Figure 5-7  Work Team Application - Example 2 ............................................................... 118
- Figure 5-8  Work Team Application - Example 3 ............................................................... 118

Chapter 6  What is Scheduling? Schedule Types

- Figure 6-1  Earned Value Project Management: The Process ........................................... 138
- Figure 6-2  Planning and Scheduling .................................................................................. 138
- Figure 6-3  Gantt Chart ..................................................................................................... 142
- Figure 6-4  Milestone Chart .............................................................................................. 142
- Figure 6-5  Bar Chart ......................................................................................................... 143
- Figure 6-6  Combination Chart ...................................................................................... 143
- Figure 6-7  Modified Bar/Milestone Chart ....................................................................... 144
- Figure 6-8  Process Flowchart ......................................................................................... 144
- Figure 6-9  Set Back Chart .............................................................................................. 144
- Figure 6-10  Line of Balance Chart ................................................................................ 144
- Figure 6-11  Network Diagrams ....................................................................................... 145

Chapter 7  Introduction to Network Logic Development

- Figure 7-1  Earned Value Project Management: The Process ........................................... 154
- Figure 7-2  Planning and Scheduling ................................................................................ 154
- Figure 7-3  PDM Networks ............................................................................................... 155
- Figure 7-4  Finish to Start ................................................................................................. 155
- Figure 7-5  Finish to Finish ............................................................................................. 155
- Figure 7-6  Start to Start ................................................................................................. 156
- Figure 7-7  Start to Finish .............................................................................................. 157
- Figure 7-8  Time-Phased Diagrams - Variable Box Length ............................................. 158
- Figure 7-9  Time Phased Bar Chart ................................................................................. 158

Chapter 8  Critical Path Method Fundamentals

- Figure 8-1  Earned Value Project Management: The Process ........................................... 164
- Figure 8-2  Planning and Scheduling ................................................................................ 164
- Figure 8-3  Critical Path .................................................................................................. 165
- Figure 8-4  Standard Notation ......................................................................................... 166
- Figure 8-5  Forward Pass (Activity Early Dates) ............................................................... 167
- Figure 8-6  Forward Pass (Activity Relationship Early Dates) .......................................... 167
- Figure 8-7  Forward Pass (Early Dates - Converging Paths) ............................................ 167
- Figure 8-8  Forward Pass ................................................................................................. 167
- Figure 8-9  Backward Pass (Activity Late Dates) ............................................................ 168
- Figure 8-10 Backward Pass (Activity Relationship Late Dates) ....................................... 168
- Figure 8-11 Backward Pass (Late Dates - Converging Paths) ......................................... 168
- Figure 8-12 Backward Pass ............................................................................................ 169
- Figure 8-13 Early, Late Dates and Total Float - the Critical Path ....................................... 169
- Figure 8-14 Free Float Calculation .................................................................................. 170
- Figure 8-15 Total and Free Float .................................................................................... 170
- Figure 8-16 Impact of Directed Finish Date - Negative Float .......................................... 171
- Figure 8-17 Impact of Directed Finish Date - Positive Float ............................................ 172

Chapter 9  Resource Loading and Leveling the Schedule

- Figure 9-1  Earned Value Project Management: The Process ........................................... 190
Chapter 10  Considerations for Developing a Useful, Quality Schedule

Figure 10-1  Earned Value Project Management: The Process .................................................. 204
Figure 10-2  Planning and Scheduling ................................................................. 204
Figure 10-3  Top Level Schedule - Contractual Milestones .............................................. 205
Figure 10-4  ‘Unit A’ Top Level Schedule ................................................................. 205
Figure 10-5  ‘Unit A’ Widgets 1 and 2 Engineering Schedule ............................................ 206
Figure 10-6  ‘Unit A’ Widget 1 Engineering Schedule ...................................................... 206
Figure 10-7  Integrated Master Plan for the Widget Project ............................................... 207
Figure 10-8  Coding Relationship Between WBS, IMP, IMS ........................................... 208
Figure 10-9  Hammock .............................................................. 209
Figure 10-10  Summaries Using Code Fields .............................................................. 209
Figure 10-11  Grouping Facility Showing Total Float by CAM ......................................... 210
Figure 10-12  Templates ................................................................. 211
Figure 10-13  Legend for the Examples ................................................................. 212
Figure 10-14  Finish to Start with Lag ................................................................. 213
Figure 10-15  Start to Start with Lag ................................................................. 213
Figure 10-16  Finish to Finish with Lag ................................................................. 213
Figure 10-17  Parallel Start to Start and Finish to Finish Relationships with Lags .......... 213
Figure 10-18  CPM Calculations - Start to Start Relationship ........................................... 214
Figure 10-19  CPM Calculations - Finish to Finish Relationship ........................................ 214
Figure 10-20  CPM Calculations - Activity B Date Possibilities ......................................... 214
Figure 10-21  CPM Calculations - Activity B Dates ....................................................... 214
Figure 10-22  CPM Calculations - Effective Duration for Activity B .................................... 215
Figure 10-23  Schedule Margin Using Buffer Activity ..................................................... 216
Figure 10-24  Qualitative Selection Criteria for Schedule Detail ............................................ 220
Figure 10-25  Missing Logic - Goal: 5% or Less .............................................................. 221
Figure 10-26  Leads - Goal: 0% ........................................................................ 222
Figure 10-27  Lags - Goal: 5% or Less ........................................................................ 222
Figure 10-28  Relationship Goals ........................................................................ 222
Figure 10-29  Hard Constraints - Goal: 5% or Less .......................................................... 223
Figure 10-30  High Total Float of 44 Working Days or More - Goal: 5% or less ................ 223
Figure 10-31  Negative Float - Goal: 5% or Less .............................................................. 223
Figure 10-32  Durations Greater than 44 Working Days - Goal: 5% or less ....................... 224
Figure 10-33  Invalid Dates - Goal: 0% ........................................................................ 224
Figure 10-34  Missing Resources on Activities with Durations of 1 Day or More - Goal: 0% . 224
Figure 10-35  Missed Activities - Goal: < 5% ................................................................. 225
Figure 10-36  Critical Path Test, Before and After .............................................................. 225
Figure 10-37  CPLI Graphic Highlighting the .95 Threshold .............................................. 226
Figure 10-38  Baseline Execution Index ........................................................................ 226
Figure 10-39  Health Check/GASP Correlation ............................................................... 227

Chapter 11  Crashing the Network

Figure 11-1  Earned Value Project Management: The Process ........................................... 236
Figure 11-2  Planning and Scheduling ................................................................. 236
Figure 11-3  Activity “Crashing” Concept ................................................................. 237
Figure 11-4  “Crashing” a Network - An Example ........................................................ 238
Figure 11-5  Step 1 and Step 2: “6 Weeks” ................................................................. 238
Figure 11-6 Step 3 - Identify Crash Time and Crash Costs for Each Activity .......................... 239
Figure 11-7 Cost of Crashing Activity "A" .......................................................... 239
Figure 11-8 Step 4 ...................................................................................... 240
Figure 11-9 Step 5 and Step 6 ............................................................... 240
Figure 11-10 Step 7 ...................................................................................... 241
Figure 11-11 Alternatives ..................................................................................... 241
Figure 11-12 9 Weeks Cost .................................................................................. 242
Figure 11-13 8 Weeks Cost .................................................................................. 242
Figure 11-14 7 Weeks Schedule ........................................................................ 243
Figure 11-15 7 Weeks Cost .................................................................................. 243
Figure 11-16 Project Cost vs. Time Relationship - The Tradeoff Curve ................. 244

Chapter 12 Setting a Traceable Schedule Baseline
Figure 12-1 Earned Value Project Management: The Process .............................. 250
Figure 12-2 Planning and Scheduling ................................................................. 250
Figure 12-3 Horizontal Traceability Between Same Level of Detail ................. 251
Figure 12-4 Vertical Traceability Between Different Levels of Detail ............... 251
Figure 12-5 Milestones ....................................................................................... 252
Figure 12-6 Vertical Traceability Coding Schema ............................................. 253
Figure 12-7 Baseline Change Request ................................................................ 254

Chapter 13 Updating the Schedule
Figure 13-1 Earned Value Project Management: The Process .............................. 268
Figure 13-2 Planning and Scheduling ................................................................. 268
Figure 13-3 Calendar .......................................................................................... 269
Figure 13-4 Impact of Status on Duration and Float ........................................... 271
Figure 13-5 PDM Network ................................................................................. 273
Figure 13-6 Schedule Bar Chart ........................................................................ 273
Figure 13-7 Out-of-Sequence Progress - Retained Logic Option (PDM Network) . 274
Figure 13-8 Out-of-Sequence Progress - Retained Logic Option (Bar Chart) ...... 274
Figure 13-9 Out-of-Sequence Progress - Progress Override Option (PDM Network) . 275
Figure 13-10 Out of Sequence Progress - Progress Override Option (Bar Chart) .......................... 276
Figure 13-11 Impact on Total Float - Sample Network ........................................ 277
Figure 13-12 Impact on Total Float - Retain Logic Option .................................. 277
Figure 13-13 Impact on Total Float - Progress Override Option .......................... 278

Chapter 14 Schedule Changes
Figure 14-1 Earned Value Project Management: The Process .............................. 284
Figure 14-2 Planning and Scheduling ................................................................. 284

Chapter 15 Resolving Negative Float
Figure 15-1 Earned Value Project Management: The Process .............................. 296
Figure 15-2 Planning and Scheduling ................................................................. 296
Figure 15-3 Trend in Float by Path ..................................................................... 297
Figure 15-4 Baseline vs. Current - Date and Duration Variances ....................... 298
Figure 15-5 Resolution Alternatives ................................................................. 301
Figure 15-6 Analysis - Most Critical Activities ................................................... 302
Figure 15-7 Analysis - Number of Critical Activities ......................................... 302
Figure 15-8 Analysis - Number of Activities On or Behind Schedule ............... 303

Chapter 16 Special Networking Considerations
Figure 16-1 Earned Value Project Management: The Process .............................. 308
Figure 16-2 Planning and Scheduling ................................................................. 308
Figure 16-3 Start Not Earlier Than Constraint ................................................... 310
Figure 16-4 Delayed Activity Using a Milestone ................................................ 310
### Chapter 17 Schedule Risk Assessment

| Figure 17-1 | Earned Value Project Management: The Process | 326 |
| Figure 17-2 | Planning and Scheduling | 326 |
| Figure 17-3 | Risk Assessment with CPM | 327 |
| Figure 17-4 | Risk Assessment with CPM Network | 327 |
| Figure 17-5 | Risk Analysis of the Project | 328 |
| Figure 17-6 | Building Foundation Activity | 331 |
| Figure 17-7 | Most Likely and Average Durations | 331 |
| Figure 17-8 | Low and High Possible Durations | 332 |
| Figure 17-9 | Risk Analysis of Path Duration Example | 333 |
| Figure 17-10 | Constructing the S-Curve | 333 |
| Figure 17-11 | Likelihood of Slippages and Contingencies | 334 |
| Figure 17-12 | Cumulative Distribution for Path A | 334 |
| Figure 17-13 | Validity of CPM Estimates | 335 |
| Figure 17-14 | Identifying the Highest Risk Path | 335 |
| Figure 17-15 | Identify the Highest Risk Path | 336 |
| Figure 17-16 | Merge Bias at Convergence | 337 |
| Figure 17-17 | Direct Dates | 337 |
| Figure 17-18 | Reducing Durations to Fit the Schedule | 338 |
| Figure 17-19 | Two Path Example | 338 |
| Figure 17-20 | Late Starts on Path B | 339 |
| Figure 17-21 | Early Starts on Path B | 339 |
| Figure 17-22 | Schedule Risk Histogram | 341 |
| Figure 17-23 | Cost Risk Histogram | 342 |
| Figure 17-24 | Standard Deviation | 343 |
| Figure 17-25 | Six Activity Network Example | 343 |
| Figure 17-26 | PERT Calculations | 344 |
| Figure 17-27 | Distribution Curve for Path U-V-X-Z | 344 |
| Figure 17-28 | Distribution Curve for Path U-W-Y-Z | 344 |

### Chapter 18 Scheduling in a Performance Measurement Environment

| Figure 18-1 | Earned Value Project Management: The Process | 364 |
| Figure 18-2 | Planning and Scheduling | 364 |
| Figure 18-3 | Schedule Integration - Schedules Must Tier | 367 |
| Figure 18-4 | WBS Levels vs. Schedule Levels | 367 |
Chapter 19  The Estimating Process
Figure 19-1  Earned Value Project Management: The Process ........................................... 388
Figure 19-2  Estimating Topics ......................................................... 388
Figure 19-3  Levels of Estimate Detail 1 ........................................... 393
Figure 19-4  Levels of Estimate Detail 2 ........................................... 393

Chapter 20  Types of Estimates
Figure 20-1  Earned Value Project Management: The Process ........................................... 396
Figure 20-2  Estimating Topics ......................................................... 396
Figure 20-3  Types of Estimates ..................................................... 399

Chapter 21  Estimate Development
Figure 21-1  Earned Value Project Management: The Process ........................................... 402
Figure 21-2  Estimating Topics ......................................................... 402
Figure 21-3  The Estimating Process .................................................. 403
Figure 21-4  Inputs for Estimate Development .......................................... 406
Figure 21-5  Estimate Outputs .......................................................... 407
Figure 21-6  Estimate Development Example 1 ...................................... 408
Figure 21-7  Estimate Development Example 2 ...................................... 409
Figure 21-8  Estimate Development Example 3 ...................................... 409
Figure 21-9  Estimate Development Example 4 ...................................... 409
Figure 21-10  Level of Detail Summarization ........................................ 410

Chapter 22  Learning Curves
Figure 22-1  Earned Value Project Management: The Process ........................................... 426
Figure 22-2  Estimating Topics ......................................................... 426
Figure 22-3  Learning Curve - Normal Coordinates ......................................... 427
Figure 22-4  Learning Curve - Log-Log Coordinates ......................................... 427
Figure 22-5  Learning Curve Showing End of Production Inefficiencies .................. 430

Chapter 23  Cost Risk Assessment
Figure 23-1  Earned Value Project Management: The Process ........................................... 436
Figure 23-2  Estimating Topics ......................................................... 436
Figure 23-3  Other Considerations ...................................................... 438
Figure 23-4  Uniform Probability Distribution ........................................... 438
Figure 23-5  Triangular Distribution ..................................................... 438
Figure 23-6  Actual Risk Simulation Results .......................................... 438
Figure 23-7  Cumulative Probability Curve 1 ........................................ 439
Figure 23-8  Increased Iterations .......................................................... 439
Figure 23-9  Right Skewed Example .................................................... 440
Figure 23-10  Kurtosis Example .......................................................... 440
Figure 23-11  Other Considerations Example 1 ...................................... 441
Figure 23-12  Other Considerations Example 2 ...................................... 441
Figure 23-13  Other Considerations Example 3 ...................................... 442

Chapter 24  Estimate Review
Figure 24-1  Earned Value Project Management: The Process ........................................... 446
Figure 24-2  Estimating Topics ......................................................... 446

Chapter 25  Tracking the Estimate
Figure 25-1  Earned Value Project Management: The Process ........................................... 454
Figure 25-2  Estimating Topics ......................................................... 454
Figure 25-3  Estimate Traceability ....................................................... 456
Figure 25-4  Estimate History Form ($ x 1000) ........................................ 456
Chapter 26  Automating the Estimating Function
Figure 26-1  Earned Value Project Management: The Process ................................. 466
Figure 26-2  Estimating Topics ................................................................. 466

Chapter 27  Earned Value
Figure 27-1  Earned Value Project Management: The Process ......................... 480
Figure 27-2  Budget Plan vs. Actuals ..................................................... 481
Figure 27-3  Overrun or Ahead of Schedule? ............................................. 481
Figure 27-4  Planned Accomplishment ...................................................... 482
Figure 27-5  Earned Value of a Task .......................................................... 482
Figure 27-6  Planned vs. Actual Accomplishment ....................................... 482
Figure 27-7  What’s Been Accomplished? What did it Cost? ......................... 483
Figure 27-8  Earned Value is a Good Approximation .................................... 483
Figure 27-9  Cost Variance ........................................................................ 483
Figure 27-10  Schedule Variance ............................................................... 483
Figure 27-11  Cost and Schedule Impacts .................................................. 484

Chapter 28  The Brick Wall
Figure 28-1  Budget vs. Actuals ................................................................. 489
Figure 28-2  Four Days of Bricking ............................................................. 490
Figure 28-3  Budget vs. Actual Day Five .................................................... 490
Figure 28-4  Planning Using Earned Value ................................................ 491
Figure 28-5  Detailed Planning for Day One Using Earned Value .................... 491
Figure 28-6  Earned Value after Day One .................................................... 492
Figure 28-7  Earned Value Status Day One ................................................ 492
Figure 28-8  Earned Value Status Day Two ............................................... 493
Figure 28-9  Earned Value Status Day Three ............................................. 493
Figure 28-10  Earned Value Status Day Four ............................................ 493
Figure 28-11  Earned Value Status Day Five .............................................. 494
Figure 28-12  Earned Value Graphics ......................................................... 494

Chapter 29  Measuring Accomplishment
Figure 29-1  Earned Value Project Management: The Process ......................... 500
Figure 29-2  Incremental Milestone - Planning ......................................... 504
Figure 29-3  Incremental Milestone - Status .............................................. 504
Figure 29-4  50% / 50% - Planning ............................................................. 505
Figure 29-5  50% / 50% - Status ................................................................. 505
Figure 29-6  0% / 100% - Planning ............................................................. 506
Figure 29-7  0% / 100% - Status ................................................................. 506
Figure 29-8  Units Complete - Planning ..................................................... 507
Figure 29-9  Units Complete - Status ........................................................ 507
Figure 29-10  Percent Complete - Planning ............................................. 510
Figure 29-11  Percent Complete - Status ................................................ 510
Figure 29-12  Apportioned Effort - Planning and Status .............................. 511
Figure 29-13  Level of Effort (LOE) - Planning ......................................... 512
Figure 29-14  Level of Effort (LOE) - Status ............................................ 512

Chapter 30  Establishing the Performance Measurement Baseline
Figure 30-1  Earned Value Project Management: The Process ......................... 520
Figure 30-2  Performance Measurement Baseline ....................................... 521
Figure 30-3  Rolling Wave Example 1 ....................................................... 521
Figure 30-4  Rolling Wave Example 2 ....................................................... 522
Figure 30-5  Reporting Structure Data Matrix .......................................... 523
Figure 30-6  Total Project Cost Distribution ............................................. 523
Figure 30-7  Elements of the Base and the Baseline .................................. 523
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Collecting Actual Cost</td>
<td>Figure 31-1, 31-2, 31-3, 31-4, 31-5, 31-6, 31-7, 31-8, 31-9, 31-10</td>
<td>524</td>
</tr>
<tr>
<td>32</td>
<td>Performance Measurement Calculations and Estimates at Completion</td>
<td>Figure 32-1, 32-2, 32-3, 32-4, 32-5, 32-6, 32-7, 32-8, 32-9, 32-10, 32-11, 32-12, 32-13, 32-14, 32-15, 32-16, 32-17</td>
<td>546</td>
</tr>
<tr>
<td>33</td>
<td>Variance Analysis and Corrective Action</td>
<td>Figure 33-1, 33-2, 33-3, 33-4, 33-5, 33-6, 33-7, 33-8, 33-9</td>
<td>574</td>
</tr>
<tr>
<td>34</td>
<td>Baseline Revisions and Change Control</td>
<td>Figure 34-1, 34-2, 34-3, 34-4, 34-5, 34-6, 34-7, 34-8, 34-9, 34-10, 34-11, 34-12</td>
<td>586</td>
</tr>
<tr>
<td>35</td>
<td>Subcontract Management</td>
<td>Figure 35-1, 35-2, 35-3, 35-4, 35-5, 35-6, 35-7, 35-8, 35-9, 35-10, 35-11</td>
<td>604</td>
</tr>
</tbody>
</table>
Figure 35-4  Subcontract EVM System and Reporting Requirements .......................... 606
Figure 35-5  Prime Contract/Subcontract Integration (1 of 2) ................................. 607
Figure 35-6  Prime Contract/Subcontract Integration (2 of 2) ................................. 608
Figure 35-7  Planning the Definitized Subcontract .................................................. 609
Figure 35-8  BCWS Time Phasing for Prime Control Accounts (1 of 2) .................... 610
Figure 35-9  BCWS Time Phasing for Prime Control Accounts (2 of 2) .................... 610
Figure 35-10 Allocation Example .............................................................................. 610
Figure 35-11 The Subcontractor’s MR and UB ......................................................... 611
Figure 35-12 Prime Contractor Establishes BCWS Based on Subcontractor Submittals .... 612
Figure 35-13 Factoring Objectives ............................................................................ 614
Figure 35-14 Badgeless Organization RAM ............................................................. 616
Figure 35-15 Class I Change Cycle ........................................................................... 617
Figure 35-16 Class II Change Cycle .......................................................................... 618
Figure 35-17 Over Target Baseline and Schedule ..................................................... 619

Chapter 36  Implementation of the Project Management Process

Figure 36-1  Earned Value Project Management: The Process ................................. 638
Figure 36-2  Implementation of the Project Management System .............................. 639
Figure 36-3  Baseline Schedule Development Flowchart ......................................... 640
Figure 36-4  Performance Measurement Flowchart ............................................... 643
Figure 36-5  Implementation Schedule ................................................................. 646
Preface

This book is about project management. It is not about all aspects of project management but it includes some of the most important aspects. This book is about how the planning, control, and management of projects can be improved through the use of the concept called Earned Value.

This book is intended for anyone who desires to know more about project planning and control and how to improve these processes through the use of Earned Value. Intended readers include project and program managers, project control personnel, project technical personnel, procurement activity personnel and the stakeholders and owners of projects. While it is intended for a wide range of readers, each is assumed to have a basic familiarity with the requirements and the disciplines of project management. Readers new to this arena would be well advised to supplement this reading with a basic but general work on Project Management.

The material in this book as been drawn from the collective experiences of the author and many of the professional personnel of Humphreys & Associates, Inc., consultants in project and program management for over forty years. This material has been presented in seminars, workshops and successfully used assisting our clients in the United States and around the world. While introductory theory is explained, time tested samples are provided. Samples are presented from specific industries. Please do not conclude that a sample does not apply to those of you in the construction, software, or other industries.

To facilitate the learning experience, the topics covered are linked together in a process flowchart. This flowchart is displayed at the beginning of each chapter and the elements of the flowchart addressed in that chapter are highlighted. In addition, the chapters have been grouped into Sections. Each Section represents a major activity in the planning and control process, Organization, Scheduling, Estimating, and Earned Value. These are supplemented by a Section on Implementation (of project planning and control) and by a Conclusion and an Appendix.

To further aid the reader, a series of questions about chapter content are found at the conclusion of each chapter. The answers are provided in the Appendix. In addition, at the end of each Section there is a Section Quiz. Again the answers are provided in the Appendix. Finally, the majority of chapters contain one or more Case Studies. These are practical exercises that have been drawn from our consulting experiences and presented in Humphreys & Associates, Inc. seminars and workshops. The Case Studies have been found to reinforce the participants learning. Suggested solutions to these Case Studies can be found on our website at: www.humphreys-assoc.com.
Chapter 1

PROJECT MANAGEMENT USING EARNED VALUE

Objectives of this Chapter:
1. Define “project” and project management.
2. Describe the performance-oriented approach using an Earned Value Management System and explain why it is superior to actual versus budget comparisons.
3. Discuss factors affecting the appropriate level of detail for Earned Value implementation.
4. Introduce the process flowchart for the Earned Value Project Management process.

What is a Project?
Before delving into the intricacies of the Earned Value Management process, projects and Earned Value Management need to be defined first. A project consists of a defined objective to develop or produce a new product, capability, or to expand capacity within a specified time frame and budget. Examples of projects include large capital-intensive efforts such as highway construction, new commercial buildings, power plants and petrochemical plants, water treatment plants, flood control, dams, bridges, hospitals, schools, prisons, and churches. These are the obvious, highly visible projects.

They are not the only types of projects; however, as new product development is also a project. A new automobile, engine, or communication satellite is a project. Other projects include research and development, definition of new information systems, design and installation of communication systems, creation of new software programs, and computer hardware advances.

Projects are so widespread that it is difficult to get through the day without being involved in some way with a project, whether it is sitting in traffic while road work continues, finding a more efficient information flow for office communication, or managing a home improvement.

The Project Management Institute (PMI) defines a project as:

> A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the project’s objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or the need for the project no longer exists.¹

A well conceived project could also be characterized as any endeavor that has a well-defined scope of work and optimistic yet achievable schedule and cost objectives.

The words “project” and “program” are sometimes used interchangeably in industry, resulting in some confusion. A program is made up of individual projects to be accomplished. For example, the inertial guidance system for an aircraft may be a separate project on a program. Because

---

projects and programs share the same characteristics they can be treated in a similar manner. For that reason, throughout this text, the term “project” will be used generically to refer to both projects and programs.

Now that project has been defined, what is Earned Value Management? It is the process of defining and controlling the project so that defined objectives are met. The controlling aspect includes scope control, schedule control, and budget control. It also includes the process of identifying and minimizing risk. There are many aspects involved in Earned Value Management, including development of the Earned Value Management System. An Earned Value Management System is a set of processes and tools used to facilitate the management of a project.

Managing Projects

Many projects result in highly successful completions. Successful projects contain many common characteristics: they were well defined and organized, had a closely monitored work scope, had optimistic yet achievable schedule and budget from the time of initiation, and were closely monitored and managed. Many projects have been successful for another reason: they benefited from mistakes on other projects. The primary factor observed on successfully managed projects is managing performance. The common thread throughout all of the topics in this textbook is exactly that.

The approaches and techniques that will be discussed have a performance measurement orientation, because the better something can be measured, the better it can be managed.

In a performance measurement system, cost and schedule targets are assigned to each activity planned in a project and to the project itself; progress (performance) is measured against these targets. Deviations from the activity targets and the causes of the deviations are identified and action is taken to minimize adverse consequences to the project.

Projects require expertise from many disciplines. Close coordination and communication are essential parts of successful execution of a project. To achieve these, a separate “project team” is typically assembled for accomplishing the project’s scope of work. This team is organized using individuals from various disciplines such as accounting, purchasing, engineering, manufacturing, testing, operations, finance, contracts, construction, project controls, and may also include subcontractors. Some people provide part time support to a project. These might include any of those mentioned above and others such as the legal department, record retention, financial services, and executive management.

The job of managing all of these organizations and people is typically assigned to a full time senior individual who is designated as the project manager. A project manager should meet several specific qualifications: many years of experience in the type of project being managed to be technically qualified; a degree to be academically qualified; and stamina to be physically qualified. In addition, project managers must have good processes and tools to effectively manage the people and the project.

The project manager must orchestrate the entire project to achieve the technical, schedule, and cost objectives. If a project is an internal endeavor, then a project manager’s role is to manage the internal departmental interfaces and contractors, and possibly other owners and customers, in addition to all of the internal staff.

Unlike normal functional organizations, a project has a specific duration. Even as a project is initiated, its purpose is to accomplish defined objectives and disband. A project team’s job is to quickly accomplish the technical scope of work, resource as efficiently as possible, and then move on to the next project. The project manager’s job is, therefore, inherently complex and challenging. Besides the interfaces that must be managed on a daily basis, he or she must often be a motivational expert since the many players involved may have different goals. For many reasons, a project manager has a great need for accurate status information. Only with reliable indication of project status can concerns be surfaced early enough to allow corrective action, preventing potential concerns from becoming real concerns that adversely impact technical, schedule, and cost objectives.
Examples used throughout this text are extracted from actual experiences. Frequently it is easier to illustrate a concept by showing what can or will happen if certain fundamentals are ignored than what happens if they are followed. If the principles in this text are followed, there is a good probability of executing a well-managed project. If they are ignored, unpleasant, career-limiting, unsuccessful experiences can occur.

Depending on project risk, project duration, and cost, (technical, schedule, and cost), certain aspects may be implemented less stringently. The principles do not change. It is still necessary to define the scope of work, have a plan for accomplishing the work, and to manage the plan. However, the level of detail of the implementation can vary. Unsuccessful applications of these principles have also happened when organizations went overboard on the level of detail of implementation. If common sense is forgotten, it is possible to create a management system that requires so much effort that it requires and extensive staff just to provide the production and distribution of data. The cost of the management system is then not worth the additional insight received regarding project status.

The Earned Value Management tools that are recommended in this book have been effectively used to improve management on numerous projects. By selectively employing tools, the practitioner will improve management on current and future projects and thus, the prospects for project success.

There are several other topics related to Earned Value Management that are not directly covered. These include contract administration, project administration, and material and subcontract management. These are, however, incorporated within the discussions of related subjects generally performed by these functions.

The contract type has an impact on the extent of Earned Value Management implementation, but all of the basic information is still necessary to ascertain project status regardless of the contracting arrangement. Experience shows that too much attention is placed on the type of contract rather than incorporating all of the information, but at a different level of detail.

The human aspects of Earned Value Management must not be forgotten either. As mentioned before, the project manager needs to be a motivational expert. The project manager also needs a strong supporting staff. No single person can successfully perform all of the work involved in a major project. He or she must rely on the support of many others. This makes the project a team effort. Even the best systems will be less effective in the hands of individuals who do not cooperate with each other and do not work towards a common goal. An underlying assumption is that effective management tools will facilitate better management of a project and minimize the confusion that results from a project that is not well defined and planned.

Background

In the past few decades, many large projects in numerous industries experienced significant schedule delays and cost overruns. Nuclear power projects stretched for years beyond their original schedule and more than tripled in cost. Software development projects in most companies required so much lead-time that the intended users had to find alternative ways of accomplishing their goals. In other cases, competitors beat software development firms to the marketplace and millions of dollars were wasted. Water treatment and sewer treatment plants soared in cost, with immediate impact on the consumer’s water bill. Research and development projects and military projects were cancelled because of continuously escalating schedule and cost projections. The U.S. auto industry suffered from a perceived lack of quality and unit prices increased. Many of these cases became highly visible to a large number of people.

For the project managers, the owners, and customers of these projects, this was not the objective envisioned in the project plan. How did this happen?

Causes were both internal and external. Scope changes occurred without being recognized and incorporated into a revised plan for accomplishing the work. Customer needs changed, sometimes because of a delay in finishing a product, thus resulting in obsolescence. Delays in mate-
ternal delivery occurred without properly reflecting the impact to other work activities. Regulations changed, frequently affecting the time needed to acquire permits or authority to proceed. Lack of coordination between contributing groups meant delays because of missing information, design or otherwise. When these and other disruptions occurred, resulting schedule slippage had large cost impacts because of high rates of escalation. Every delay was penalized with a significant negative economic consequence.

Typically a domino effect is observed. First, a technical problem occurs. This is followed by a negative schedule variance and ultimately a negative cost variance. Sometimes the dominos fall very fast, but problems could evolve over months.

Regardless of the source of difficulty, the underlying problem was that impacts were not recognized quickly enough when conditions changed. In some cases, project managers were ignoring variances from the plan and failing to take action because they did not believe the variances were real. In others, they were not informed well enough about the variances. The situation was much like that shown in Figure 1-1.

In Figure 1-1, the Estimate at Completion (EAC) is below budget throughout most of the life of the project. While challenges were faced daily in the management process, there was no way to quantitatively assess the impact in a timely manner. By the time a schedule slip or an overrun was forecast, it was too late to do anything to minimize its impact. The result was shocking surprises.

This scenario occurred often enough that there was a heightened awareness of the technical, schedule and cost risk associated with projects. Because of this risk, many organizations reacted by creating better management systems. These systems provided the capability of integrating all of the available data into a cohesive form so that better visibility would result. One of the greatest challenges for these systems was timeliness. If information were not available until after the fact, all that would be accomplished from its use was a well documented history of what went wrong rather than an effective tool for management during the life of the project. This improved visibility must allow for earlier identification of trends so that situations like the one pictured in Figure 1-1 can be prevented.

Most projects develop a time phased plan to accomplish the work. This resembles an S-curve shape. In the early stages, staffing and progress may be slow. In the middle part of the curve, both staffing and progress should be at their peak. At the end of the curve, progress slows while actual staffing may still be at peak or near-peak levels. The implications are obvious: identify and address the problems earlier in the project life and there is a much greater chance of avoiding schedule slips and large cost overruns. Early in the project, it takes very few additional resources to accelerate and resolve variant conditions. At the peak of the project activity, it takes enormous resources just to stay even with the progress curve, making catch-up very difficult. Even worse, at the end of a project, even great cost expenditures may do little to accelerate technical and schedule progress. Improved early visibility is a primary objective of any project management system.

The Performance-Oriented Approach

Every company has some sort of tracking system to indicate how it is performing. Unfortunately, in many cases, the tracking may have been no more sophisticated than what is shown in Figure 1-2, Budget Plan versus Actual Cost. This was
the traditional approach used for many years in companies and is still used in too many organizations.

Actual costs are collected and compared with budgeted costs. This is done in the only common denominator available for resources - dollars in the U.S., Canada, and Australia, or the corresponding local currency in other countries. Does this approach provide improved visibility?

A good system must provide status and, therefore, the necessary visibility into progress. The graph shown in Figure 1-2 at least allows comparison of expenditures with what was planned to be spent. However, there is no assurance that project status is known. Actual cost to date is higher than planned, but does that indicate a cost overrun or is the project ahead of schedule? This situation is shown in Figure 1-3.

A budget versus actual comparison is shown in Figure 1-4. This may appear to indicate that a cost underrun is occurring. However, there is no basis for projecting what status will be at project completion. It may be that the project is incurring a cost underrun, but it may also be that the project is behind schedule and future expenditures will accelerate significantly. This is shown in Figure 1-5.

What is missing from the comparison shown in Figures 1-4 and 1-5? There is no measure of what has actually been accomplished for what has been spent. The fact that money was being spent slower than planned could mean that there would be a cost underrun. It could just as easily mean that the project is behind schedule, or both, or neither.
The key to knowing what the true progress and status actually are requires the addition of a third line to the curve that reflects the dollar value for the work that has been completed.

This third line results from a “performance-oriented” approach. This approach shifts the emphasis from expenditures to work accomplishment. The project objective should be to accomplish all of the work rather than to spend all of the money.

When using a performance oriented approach, work scope and associated responsibilities must be defined in the initial planning phase of the project. This is a far better approach than defining responsibility in some form of finger-pointing exercise of guilt determination after a crisis occurs. It allows the person responsible for an emerging variance to take action before it becomes a problem. The entire organization benefits from this approach. If action cannot be taken in time to entirely avoid a problem, at least the impact can be accurately assessed if there were an objective method of measuring progress. By setting variance standards or “thresholds”, the system can be used as a high level Management by Exception indicator. A result is the ability to develop improved forecasts of technical performance, scheduled completion, and final cost earlier in the project. The third line that represents work accomplishment has been added to Figure 1-6.

With this type of information, it is possible to project schedule slippage and cost overrun in early stages of the effort. This early warning feature is one of the most important advantages of including a measure of work accomplished. Figure 1-7 illustrates how these projections might be represented.

Now there is a completely different picture of the project status. This graphic depicts the value of the work scheduled to be accomplished, the value of the work accomplished, and how much the accomplished work actually cost. Actual costs to date are still below the budget line, but the value of work accomplished is even less. In other words, cost is not underrunning, but in fact is overrunning relative to the value of the work accomplished. Similarly, a behind schedule condition is apparent. The various methods for measuring the accomplishment of work will be presented in later chapters of this text, but the important point is that it can be measured and compared with an approved plan.

Summary Implementation Concerns

The Earned Value Management process concepts are appropriate in any single project or multi-project environment. On any type of project in any industry, regardless of how small it is, a project must be effectively defined to be effectively accomplished. A project cannot be completed if its scope is not understood. Individuals or organizations must be identified with responsibility for completing the work, and a time frame must be established for accomplishing that work.
Budgets and other resources that are allocated to the project need to be identified. In other words, a plan for accomplishing the work is needed. Then progress must be measured against that plan. When variances are identified, corrective action should be identified, evaluated, and implemented in the most cost effective manner. These are standard techniques that apply in any situation.

Experience shows small, short duration projects are often managed far worse than the large projects that have high visibility. Because small projects are considered less significant towards the overall profit picture, they are sometimes overlooked with very unfavorable results. When small projects ignore basic management concepts, they commonly miss their budgets by 100 to 300 percent. The accumulation of absolute dollars may be more than a large project that misses its budget by 10 percent. The point is that the summation of many poorly managed small projects could exceed the impact of a large project.

A convenient aspect of the performance oriented approach is that it works in all environments including research and development, manufacturing, testing, construction, procurement, software development, and design. It also works on all types of contracts, regardless of whether they are firm fixed price, cost plus, or some other type between these two extremes. However, these factors play an important part in deciding on the level of detailed implementation to be used.

Factors Affecting System Implementation Detail

Among the factors that will impact the selection of project controls for a particular application, are the following:

- Project size and duration.
- Technical, schedule and cost risk.
- Project contract environment.
- Management involvement level.

The size and duration of a project are critical considerations when making key decisions on desired management system characteristics. Because of the complexity of long duration, high cost projects, it is not surprising when it takes six months to develop a detailed plan for accomplishing the project objectives. Smaller projects often do not have a total of six months duration. This does not suggest that the smaller project needs no plan, but rather that it will have a less detailed plan featuring the same general requirements. Similarly, it will not make sense to set up an elaborate monthly reporting scheme with variance analysis reports and corrective action plans since the project will be completed before such a program can even be properly established. Variances still need to be identified and actions taken to correct them, but it will be a far less formal process, probably involving little documentation.

Risk is another important consideration and relates to maturity of the technology involved. If the project were the tenth in a long series of similar products or services, some simple indicators of progress over time may be all that is required. But if it were the development of a new technology, greater detail will be needed for monitoring and managing progress against the goal.

The project contract environment may impact the emphasis of controls. On a firm fixed price contract, cost monitoring and evaluation is typically not emphasized by the customer. However, the contractor will be very cost conscious, since it is responsible for any overruns when this contract type is used. From a customer’s perspective, technical and schedule considerations are also very important for firm fixed price contracts with its support contractors, especially on a multiple contractor program as the interfaces between contractors and projects must be managed. Productivity may still be a concern since it will relate to whether the schedule can be met. In a cost reimbursable environment, cost controls are a paramount consideration since the contractor can maximize income by increasing the hours required to complete the work. The level of detail for cost and schedule control systems will vary in detail accordingly.

The level of management involvement is another contributing factor to decisions regarding implementation detail. In many cases, both owner/customer and contractor will have their own systems for determining project status. The contractor
responsible for accomplishing the work will need a detailed system. However, the owner/customer should need a far less involved reporting system and could track progress on a higher level. There are exceptions to this as well. If the owner/customer were hiring the labor for the project and operating in a hands-on management situation, then detailed controls may be needed in the owner's/customer's organization.

Common sense and reason must be used when developing and implementing Earned Value Management Systems. Implementing systems at too low a level of detail and with unnecessary complexity has probably caused nearly as many problems as having no system at all. While that may be a slight exaggeration to make a point, the objective of improved visibility can be clouded just as easily by too much data (and not enough information) as it can by lacking enough input.

**Earned Value Management System Recognition**

The techniques developed and explained throughout this text were implemented widely only after it became apparent that they were necessary. They have not always been enthusiastically embraced by all project participants for various reasons. Some do not want extra visibility into the status of their work if that same information is in the hands of their boss and/or their customer. Typically, managers prefer to attempt resolution of problems before they are discovered by others. While this is understandable from a human nature standpoint, it is entirely unacceptable from a project manager’s viewpoint. If problems are hidden and not satisfactorily resolved, they will later have increasingly substantial impacts to project cost and schedule. It is essential that the project manager has the information and tools to assess status accurately, allowing more rapid, effective management decisions.

**The Earned Value Management Process**

Successful management of a project involves many concepts and implementation concerns. A project is any endeavor that has a well understood statement of work and optimistic, yet achievable, schedule and cost targets. An Earned Value Management System is a tool set used to facilitate management of a project. There are many considerations in this complex discipline. A series of flowcharts are used throughout the text to exhibit how the various chapters interrelate.

The master flowchart is shown in Figure 1-8, “Earned Value Project Management: The Process”. This chart is repeated at the beginning of each chapter to show where that chapter fits in the overall process. Individual blocks will be expanded as necessary into lower level, more detailed flowcharts for the more involved topics. This will help assure that a proper understanding of each concept is achieved.

The fundamental concept of this entire book is that the Earned Value Management process should be logical, well-defined, and integrate all of the pertinent information relating to a project’s status into a comprehensive picture. Every organization implements many of the concepts; few of them integrate those concepts into a unified status. That is the primary challenge: to use all of the tools in the tool box in a coordinated manner so that they meet the objective of improved project visibility, allowing earlier management decisions based on accurate information. This provides a project manager the best opportunity to meet project schedule and cost objectives while achieving the technical requirements.

The following is an overview of the process steps in Figure 1-8.

**The Process Steps**

**Step 1 – Project Objectives**

The first step in the process is definition of the project objectives. These objectives include a general description of the technical requirements of the project, its budget, and the timeframe for the work to be completed. A targeted starting date and a completion date are included in this description. There may even be some guidance provided as to whether this is a technical, schedule and/or cost critical project. These can be critical pieces of information: as an example, at one
of the major auto manufacturers a project to design a new bumper system was being initiated. The time for this product to reach the market was critical, with a goal of eight and a half months. However, the contractor’s project manager assumed that the project was more cost critical than schedule critical. This resulted in the project plan being stretched to 18 months to lower the peak cost requirements.

When the owners and customers reviewed the contractor’s plan, they realized that the primary objectives had not been explained clearly enough. The contractor was sent back to completely redo the plan to support the eight and a half-month requirement. If this project had been managed to the 18-month plan, it would have lost much of its commercial appeal.

The project plan is the set of documentation and directives that formalize the entire management process described in this text, including project objectives, general scope, project organization, desired schedule/cost goals, and a description of management systems and procedures to be used in completing the project. The project plan reflects the project specific internal as well as customer management, reporting, and analysis requirements. The approach used to code and organize the project data is an important up front activity to establish a standard approach to integrate the technical, schedule, cost, and risk data to generate reliable information for effective management, reporting, and analysis for the life of the project.
Step 2 – Work Scope Definition, Risk Assessment and Management

Once the project objectives have been defined, the next function that must be fulfilled is to delineate, capture, and define the entire scope of the project. This is the best opportunity to assure understanding among the various project participants. It also is the best chance to avoid later nightmares with numerous scope changes and possible litigation. The work breakdown structure (WBS) and work breakdown structure dictionary are the tools used to segregate the work into manageable components and to define each component.

A risk assessment of the technical goals is an important part of this process. Risks are identified and mitigation plans are developed. After the organization is assigned in Step 3, additional risks may be identified and the risk plans updated.

Step 3 – Responsibility Assignment, Work Teams

Once the scope is crisply defined, the next step is to document who is responsible for the work. Each component of work defined in the work breakdown structure will have one individual assigned who will be responsible for the scope, schedule and budget for that work.

It takes an entire project team working together to make the project a success, but only a single individual to cause it to fail. This explains some of the reason for the growing popularity of work teams that help break down the traditional barriers between functional work areas (i.e. departments which can also include subcontractors) and encourage a team spirit.

Work teams are composed of the functional elements necessary to develop or produce the end product. This work team structure has advantages in that fewer management accounts are needed, there is improved communication and efficiency, and potential risks often are surfaced earlier.

Step 4 – Planning

Once the work definition and organizational concerns have been addressed, the particulars of the Earned Value Management process must be developed. These include the functions of scheduling, estimating, budgeting, and performance measurement. These elements must all be performed and integrated for the baseline plan to be developed.

Step 5 – Planning and Scheduling

The scheduling process is defined as what must be done, and when it must be done, to accomplish the project objectives on time.

Step 6 – Estimating

The estimating process is defined as a forecast of how much it will cost to perform the work.

Step 7 – Definition of Earned Value and Earned Value Techniques

Determining performance measurement is accomplished through the use of Earned Value techniques, which is the key concept of the entire Earned Value Management process. While this definition has been given earlier, it is important enough to repeat here. It provides a critical element of information when project status is assessed by providing insight to what has actually been accomplished for the money that has been spent. This can also be compared with what was planned to be accomplished to allow an accurate picture of the current cost and schedule position.

Earned Value is determined through numerous techniques. The techniques selected for a project will depend on each application, but objective guidelines are available to help the selection process.

Step 8 – Schedule and Cost Risk Assessment

A topic of growing importance is that of risk assessment. This Earned Value Management process includes three components: technical risk, schedule risk, and cost risk. Each of these has its own considerations and impacts. Like the overall Earned Value Management process, these are also interrelated. There has been some tendency over the years for managers to ignore the possibilities of identifying and especially quantifying risk because the results may be disconcerting. However, ignoring risk does not
lessen its impact, and will most likely increase its effects. As profit margins become slimmer in a highly competitive environment, the topic of risk assessment must be addressed.

Step 9 – Integrated Baseline Plan and Work Authorization Development

Next we come to the center of the flowchart for a concept that is central to the overall process: performance measurement baseline development. The performance measurement baseline is the official, documented plan that shows in detail how the project objectives are to be achieved. All of the activities described thus far and the processes displayed on the Figure 1-8 flowchart are needed to achieve a well-planned performance measurement baseline. At the completion of this step, the technical, schedule, and budget baselines have been established and integrated; the schedule reflects the time frame where all of the detailed work scope is planned to be performed and the budgets are time phased based on the schedule requirements. The work is authorized to the responsible manager and the technical work commences.

Subcontract management is a critical element for many projects. The subcontractor's technical, schedule, and budget baselines must be integrated with the prime contractor baseline. Since the integrated baseline must include this element, a separate chapter on subcontract management (Chapter 35), is included in this step.

Step 10 – Establishing the Baseline Plan, Measuring Progress

At this point, there is a shift from the planning phase of baseline establishment to the control phase of the Earned Value Management process. Once the performance measurement baseline has been established, the main concern from that point on is the determination of progress. Progress is measured using the same earned value techniques that were established as part of the planning process. The techniques used when the performance measurement baseline (PMB) was established must be applied consistently when progress is determined. Progress is compared with the plan, and this comparison, in turn, provides the schedule variance.

Step 11 – Collecting Actual Costs

All projects will have a system for collection of actual costs. Regardless of how unsophisticated a system may be this component must be included. The challenge in this area is to define account structures that can be used for consistently comparing budgets, actuals, and performance. This could mean modification to existing accounting structures. Actual costs are necessary so that they can be compared with progress, and this comparison, in turn, provides the cost variance.

Step 12 – Performance Measurement Calculations

After progress is measured against the plan and the actual cost is entered, the three points necessary for data analyses are available. There are many calculations that aid in assessing the project status and assist the manager in targeting problem areas for corrective action. These calculations also assist in the Estimate at Completion and Variance Analysis reporting.

Step 13 – Estimate at Completion and Schedule Forecasting

Organizations are very concerned with bottom line performance. One of the essential pieces of corollary information needed to evaluate an ongoing project is, “When is it going to finish and what is it finally going to cost?” This answer will be used for many purposes, ranging from reward of project participants with better positions on new projects to project cancellation. The “Estimate at Completion” is so important that it can become a highly political number. A well-defined Earned Value Management System will have objective means of determining and evaluating estimates at completion to improve their accuracy even in the early stages of a project. This can only be achieved with defined performance factors that provide an accurate picture of what has happened to date and what is forecast to happen.

Step 14 – Variance Analysis and Corrective Action

Variance analysis and corrective action are very important to the overall process. Much time and effort are invested in baseline establishment, and
now the baseline information can be used as a basis for determining the course of the project. The tools defined in the previous two Steps directly feed variance analysis and corrective action. By comparing earned value to budget, schedule variances can be determined. By comparing earned value to actual cost, cost variances can be determined. The second element, corrective action, is a critical part of the control phase. At this point in the process, there is a strong basis for determining the project’s true position versus the approved plan so that exceptions can be addressed. The carefully defined system will provide immediate feedback as to whether the corrective action was successful.

**Step 15 – Baseline Revisions and Change Control**

An essential aspect of the Earned Value Management process is managing change. After all of the effort that goes into developing the baseline plan and determining current status, it is always a disruption to change that plan. Nevertheless, changes are a part of every project and must be addressed as to how they will be reviewed, approved, and incorporated into the plan. Procedures are required to manage the change control process or, over time, the project’s reports will relate less and less to the current scope, schedule, and budget as well as the true status. One guideline stipulates that as much attention is needed for processing baseline changes as was used in developing the original baseline plan.

**Step 16 – Implementation of the Project Management Process**

Now that the system design is complete, there are still some ways to streamline the information flow. These include topics such as paperless systems and electronic data integration. There are also programs available for automating much of the data reduction and analysis, with built-in sanity checks to catch obvious errors. These topics are discussed in the final chapter of this book.

**Conclusion**

A project is any endeavor that has a scope of work and optimistic yet achievable schedule and cost targets. A project is typically managed by a single individual known as a project manager, who must be able to coordinate a multi-functional team towards the achievement of all of the project objectives. One of the greatest needs of the project manager is accurate, reliable, and timely information to enable effective management decisions. The information needs to include a valid assessment of project progress and status. Projects were historically monitored by comparing planned expenditures against actual expenditures.

This approach lacks the most important element of status: a measure of work accomplished. This shortcoming can be overcome by including a third data element that determines an objective value of work completed. This is known as the performance oriented approach. The performance oriented approach allows early identification of trends that indicate if a project’s objectives are in jeopardy. This “early warning system” allows a timely response on the part of management to mitigate unfavorable outcomes by making informed decisions.

It is important that the tradeoff between adequate project status visibility and excessive data collection be recognized and addressed. This is accomplished by setting an appropriate level of detail in the implementation process. Factors that affect level of detail include project size and duration, risk (technical, schedule and cost), type of contract, and desired level of management involvement.

The entire process of managing projects must be a logical one. Each of the steps of the Earned Value Management process is illustrated by the flowchart in Figure 1-8 and will be discussed in detail in subsequent chapters.
Chapter 1 Review Questions

1-1. Explain the difference between a project and a program.

1-2. What aspects of a project are managed during the controlling phase of Earned Value Management?

1-3. How is a project organized differently from a functional organization?

1-4. What are some frequent causes of project delays?

1-5. Why is a comparison of actual costs to date versus budgeted costs not adequate from an Earned Value Management standpoint?

1-6. List at least three factors that will affect the level of detail appropriate for implementation of earned value on a project.

True or False

1-7. The Earned Value Management process is only applicable for large projects.

1-8. The fact that more money has been spent at a point in time than was planned to be spent means that an overrun in final cost is indicated.

1-9. A program may be made up of multiple projects.

1-10. Performance measurement can be successfully applied in engineering, construction, manufacturing, and software development applications, among others.

1-11. Using a measure of performance allows earlier indication of potential increases in final cost.

1-12. From the customer’s viewpoint, a firm fixed price contract suggests the need for tight cost controls.

The answers to these questions can be found in Section 6, Solutions.
Index

A
accounting calendar, 535
activity, 224
change
future duration, 285
in progress duration, 285
critical, 302
duration
status impact, 270
example statused, 269
grouping, 209
hammock, 209
level of cost collection, 535
level of effort (LOE), 319–320
missed baseline dates, 225
out of sequence, 272
relationships, 155
finish-to-finish (FF), 155
finish-to-start (FS), 155
lag, 212
lead, 212
metrics, 222
parallel finish-to-finish, 318
parallel start-to-start, 318
start-to-finish (SF), 156
start-to-start (SS), 156
summary, 209
actual cost (AC)
See actual cost of work performed (ACWP)
actual cost of work performed (ACWP), 477, 531, 536, 546
accuracy, 540
data sources, 533
labor hours versus labor dollars (reporting), 542
level of cost collection, 535
minimizing incorrect charges, 541
rates, 539
time lag, 539
actual finish date, 267
actual start date, 267
analysis
critical path method (CPM), 165
float trends, 295, 302
formulas, 545–559
formulas (list of), 713
funding, 536
labor cost variances, 558
material variances, 558
performance measurement, 545
reporting, 556
risk, 329, 341, 437
schedule network, 297–298
subcontract, 619
variance, 573
ANSI/EIA-748, 135, 363, 411, 603
apportioned effort, 511, 523
arrow diagramming method (ADM), 145, 153
B
backward pass, 166–168
badgeless organizations, 615
baseline
changes, 589
over target, 258, 524, 619
rubber, 594
schedule, 253, 259, 283, 285, 288
changes, 258, 288
establishment process, 254
establishment timing, 257
versus current, 298
baseline change request, 252, 592
baseline execution index (BEI), 225
budget
See also budgeted cost for work scheduled (BCWS)
values, 536
versus funds, 536
budget at completion (BAC), 536
budget plan
See performance measurement baseline (PMB)
budgeted cost for work performed (BCWP), 477, 481, 536, 546
calculating, 499
consistent with baseline, 503
determining when earned, 512
equipment, 536
material, 513, 536–537
purchased services, 536
rates, 539
schedule as basis, 365
budgeted cost for work scheduled (BCWS), 477, 536, 546
and work authorization, 527
estimate as basis for, 398
rates, 539
schedule as basis, 257, 365
See also performance measurement baseline (PMB)
budgeted cost of work remaining (BCWR), 551
C
cash flow, 536
change control, 585, 587
and the PMB, 588
program, 587
changes
baseline, 589
causes of, 585
directed, 617
documenting, 286, 456
duration
  future activity, 285
  in progress activity, 285
external, 585
formal reprogramming, 619
how to control, 587
internal replanning, 586, 592, 618
schedule, 283, 286
schedule baseline, 258, 288
See also change control
subcontract, 616
tracking, 590
tracking original estimate, 453
types of, 585
charge number, 522
  and work authorization, 527
commitments, 536
time lag, 536
constraint
  See directed date
Constructive Cost Model (COCOMO), 416
contract budget base (CBB), 522–524
  log, 590–591
Contract Performance Report (CPR), 556, 603
control account, 523
  and planning packages, 499
  and summary level planning package (SLPP), 522
  and work packages, 499
baseline changes, 589
dollar value, 99
duration, 99
establishment, 97
examples, 97–99
identification, 96
level of cost collection, 535
level of detail, 97–98
management responsibilities, 98
subcontract, 609, 613
corrective action log, 580
corrective action plan, 579
Cost Accounting Standards (CAS) Disclosure
Statement, 411, 531
cost baseline
  See performance measurement baseline (PMB)
cost elements, 392
cost performance index (CPI)
  combined with SPI, 556
  efficiency concept, 550
  performance concept, 550
cost risk assessment, 435–443
cost variance (CV), 483, 546
critical path, 165, 169
  characteristics, 172
  length index (CPLI), 225
test, 225
critical path length index (CPLI), 225
critical path method (CPM), 145, 165
  estimate validity, 332, 335
  fundamentals, 163
  risk approach, 330
  schedule traceability, 252
current
  schedule, 259, 283, 285, 288
  versus baseline, 298
D
direct costs, 531, 534
directed changes, 617
directed date, 171, 216, 222, 307–316
  hard constraint, 309
  imposed, 307
  not earlier than, 307
  not later than, 307
  risk analysis impact, 337
  soft constraint, 309
discrete effort, 501, 523
  0/100 technique, 506
  50/50 technique, 505
equivalent units technique, 507
  incremental milestone technique, 503
  milestones, 501
  percent complete technique, 509
  units complete technique, 506
distributed budget, 523
E
early finish (EF), 166
early start (ES), 166
earned value (EV)
  See budgeted cost for work performed (BCWP)
ed earned value management
  benefits, 485
  defined, 32
  fundamentals, 34, 479–484
  illustrated (the brick wall), 489–495
  implementation
    concerns, 36
    level of detail, 33, 37
  process, 38, 484
  relationship to risk management, 85
  schedule applications in, 363
  schedule contract requirements, 366–369
earned value management system
  continuous improvement, 644
  defined, 32
  description, 363, 640
design, 638
dollar values for compliance, 605
guidelines, 135, 363, 366, 603, 605
implementation, 637
  process, 645
  schedule, 645
interface with accounting system, 534
procedures, 644
storyboard, 642
training material, 644
earned value techniques, 509
  0/100, 506
  50/50, 505
apportioned effort, 511
consistency with baseline, 503
discrete effort, 501
equivalent units, 507
functions, 499
incremental milestone, 503
level of effort (LOE), 511
milestone, 501
other, 512
units complete, 506
escalation factors, 411–415
estimate
  automating, 465–469
  basis for BCWS, 398
  basis for EAC, 398
  changes, 453
  compared to actual
    variance sources, 453, 455
  cost flow development, 411–414
  cost risk analysis, 440
defaults, 407
defined, 389
development inputs, 406
documenting assumptions, 447
escalation factors, 411–415
fast track impact, 399
fundamentals, 387
guidelines, 390, 408–410
input sources, 407
level of detail, 410
manufacturing costs, 415
method
  analogy, 406
  engineering build-up, 406
  parametric, 406
operating costs, 415
prerequisites, 390
process, 387, 401
review
  external, 447
  other factors, 448
team, 448
role of WBS, 391–392
software, 416
  function points, 416
  lines of code, 416
templates, 391–392
traceability, 455
tracking, 453–459
type
  conceptual, 397
definitive, 398
detailed, 398
  preliminary, 397
estimate at completion (EAC), 536
  comprehensive, 549
detailed, 549
development, 548
estimate as basis for, 398
indirect, 551
justification, 580
range of, 553
estimate to complete (ETC), 536, 549
estimated completion date (ECD), 554
F
fast track, 244, 338, 399
finish-to-finish (FF), 155
finish-to-start (FS), 155
float, 163, 169
  analysis, 295, 302
  negative, 223, 295
  monitoring, 301
  resolving, 295, 300
secondary, 316
status impact, 270
formal reprogramming, 619
forward pass, 166–168
fourteen point schedule health check, 221
  activities with lags, 222
  activities with leads, 221
  baseline execution index (BEI), 225
  correlation with GASP, 226
  critical path length index (CPLI), 225
  critical path test, 225
  hard constraints, 222
  high duration, 224
  high float, 223
  invalid dates, 224
  missed activities, 225
  missing logic, 221
  negative float, 223
  no assigned resources, 224
  relationship types, 222
free float (FF), 170
freeze period, 522
funding, 524
  analysis, 536
profile, 536
funds versus budget, 536

G
GAO Best Scheduling Practices, 135, 251, 325
Generally Accepted Scheduling Principles (GASP), 134, 212, 226, 251, 365

H
hammock, 209
high duration, 224

I
independent estimate at completion (IEAC), 551
indirect costs, 411, 531, 534, 537
indirect pools, 534
integrated master plan (IMP), 205, 251
  accomplishment, 206
  coding, 207
  criteria, 207
  defined, 206
  event, 206
  IMS and WBS cross reference, 207
integrated master schedule (IMS), 205–206
  coding, 207, 252, 368
  IMP and WBS cross reference, 207
Integrated Master Schedule (IMS) Data Item Description DI-MGMT-81650, 165, 216, 252, 325, 365
integrated product team (IPT)
  See work team
internal replanning, 592, 618
International Function Point Users Group (IFPUG), 417

L
lag, 212–215
late finish (LF), 166
late start (LS), 166
latest revised estimate, 549
Latin hypercube, 437
lead, 212–215
learning curves
  cumulative average method, 427
  impacts, 429
  selecting method to use, 428
  slope, 425, 427–428
  unit method, 427
  unit values, 428–429
level of effort (LOE), 511, 523
  activities, 319–320
leveled finish, 194
leveled start, 194
logic network
  See schedule network
logs, 524, 590

M
management reserve (MR), 523–524
  log, 590
  subcontract, 610–611
milestone, 153, 251–252, 501–503, 522, 608
  examples, 503
monte carlo, 345, 437

N
negative float
  See float
nonrecurring costs, 415

O
organization breakdown structure (OBS)
  and work authorization, 527
  chart definition, 91
  intersection with WBS, 91
  types, 92
out of sequence logic, 272
  progress override, 272, 275
  retained logic, 272
total float impact, 276
over target baseline (OTB), 258, 524, 619
over target schedule (OTS), 258, 301, 619

P
percent complete, 509
  earned value technique, 509
  physical, 269–270
  project, 554
  schedule, 269–270
percent spent, 554
performance indices, 550
performance measurement baseline (PMB), 499, 519, 522
  changes, 585, 588, 590
  development steps, 520
  establishment timing, 525
  structure, 522
performance measurement calculations
  See analysis formulas
period of performance, 527
planned value (PV)
  See budgeted cost for work scheduled (BCWS)
Planning and Scheduling Excellence Guide (PASEG), 134, 366
planning package, 500
  converted to work packages, 285, 521
precedence diagramming method (PDM), 145, 153
price variance (PV), 558
Program Evaluation and Review Technique (PERT), 145, 342
progress override, 272, 275
project
  characteristics of successful, 32
defined, 31
objectives defined, 45–46
percent complete, 554
percent spent, 554
scheduling, 137
versus program, 31
R
rate variance (RV), 558
recurring costs, 415
remaining duration, 267, 270
resource
availability constraint, 192
curves, 194–195
defined, 189
ey early start curve, 194
float, 195
late start curve, 194
level dates, 194
leveled start curve, 194
plan, 189
profiles, 191
reallocation, 287
requirements, 191
time constraint, 192
usage curve, 192
resource leveling, 217
considerations, 193
process, 192–193
resource loading, 217
considerations, 193
objective, 191
process, 191
requirement, 224
responsibility assignment matrix (RAM), 91, 95–96, 524
level of detail, 96
retained logic, 272
review question answers
See solutions
revisions
See changes
risk
analysis, 329
output, 341
path duration, 332
pitfalls, 339
sampling techniques, 437
and variance thresholds, 576
assessment, 329
benefits, 329
conducting, 442
developing useful mitigation strategies, 329
implementation, 340, 345
outputs, 438–439
reasons for, 440
tools, 342
attributes, 78
classification, 78
contract type, 605
cost, 435
cumulative likelihood curves, 333
cumulative probabilities, 333
defined, 77
identification, 80
latin hypercube, 437
management
fundamentals, 77
plan, 79–80
process, 79
relationship to earned value management, 85
strategy, 84
model definition, 435
monte carlo, 345, 437
PERT, 342
probability distributions, 437
qualitative, 83
quantitative, 83
schedule, 219, 327
bias, 336
directed dates impact on, 337
fast track impact on, 338
See also schedule risk assessment (SRA)
subcontract, 605
threat or opportunity, 77
rolling wave planning, 258, 285, 288, 500, 521
root cause analysis
cost impact assessment, 559
float deterioration, 298
schedule impact assessment, 299, 559
See also variance analysis report (VAR)
S
schedule
and earned value management, 363
and work authorization (period of performance), 527
approach
aggressive, 218
conservative, 217
organizational, 218
project, 218
audit, 220
baseline, 253, 283, 285, 288
changes, 258
establishment process, 254
establishment timing, 257
basis for BCWP, 365
basis for BCWS/PMB, 257, 365
calendar, 321
changes, 283, 286
documenting, 286
duration, 285
current, 259, 283, 285, 288
current status, 259, 271
definition, 139
development data requirements, 140
earned value contract requirements, 366–369
fast tracking, 244
focused work, 244
fourteen point health check, 221
fundamentals, 137
integrating subcontract, 608
level of detail, 219, 256
margin, 216, 300
baseline finish variance method, 217
buffer activity method, 216
over target, 258, 301, 619
percent complete, 269–270
physical percent complete, 269–270
purpose, 141
quality, 220
reconciliation
progress and performance, 365
time phased budgets, 365
reserve, 216
risk, 219, 327
analysis output, 341
and cost overrun, 329
and early start scheduling, 339
and late start scheduling, 338
at path convergence, 336
bias, 336
CPM approach, 330
directed dates impact on, 337
duration validity, 338
fast track impact on, 338
highest path, 335
merge bias at path convergence, 336
other issues, 341
path duration, 332
probabilistic approach, 330
See also schedule risk assessment (SRA)
routine updates, 285, 288
status, 252, 259, 286
and SPI, 216
considerations, 272
data, 267
float analysis, 295, 302
streamlining, 244
traceability, 249, 251
achieving, 252
historical, 252, 285
horizontal, 251, 365
vertical, 251, 363
types
bar chart, 143
combination chart, 143
flow process chart, 144
gantt charts, 141
line of balance, 144
milestone chart, 142
modified gantt or milestone chart, 143
network diagrams, 145
set back chart, 144
update process, 267, 271
visibility task, 310
what if, 285, 287
work scope crosscheck, 57
schedule finish, 298
schedule network
acceleration, 235
other techniques, 244
activity relationships, 155
analysis, 297–298
backward pass, 166
calculated dates, 166, 270
calculations, 166, 170, 269
coding, 207, 252, 368
components, 153
CPM analysis technique, 165
crashing, 235
example, 237–244
process, 237
development concerns, 208
development technique
bottom-up, 206
IMP/IMS, 206
top-down, 205
directed dates, 171
display techniques, 157
forward pass, 166
out of sequence logic, 272
resource leveled dates, 194
resource loading, 191
resource loading requirement, 224
templates, 209–212
schedule performance index (SPI), 303, 551
and schedule status, 216, 555
combined with CPI, 556
schedule risk assessment (SRA), 325–346
schedule variance (SV), 303, 483, 546
converted to time variance, 547
dollar versus time, 484
secondary float, 316
slack, 163, 169
solutions
chapter 1, 653
chapter 2, 654
chapter 3, 655
chapter 4, 656
chapter 5, 657
chapter 6, 660
chapter 7, 662
chapter 8, 663
chapter 9, 664
chapter 10, 665
chapter 11, 668
chapter 12, 669
chapter 13, 669
chapter 14, 671
chapter 15, 672
chapter 16, 673
chapter 17, 674
chapter 18, 676
chapter 19, 682
chapter 20, 684
chapter 21, 684
chapter 22, 686
chapter 23, 687
chapter 24, 688
chapter 25, 689
chapter 26, 691
chapter 27, 694
chapter 28, 695
chapter 29, 696
chapter 30, 697
chapter 31, 698
chapter 32, 699
chapter 33, 702
chapter 34, 703
chapter 35, 704
chapter 36, 710
section 1 quiz, 658
section 2 quiz, 677
section 3 quiz, 691
section 4 quiz, 706
start-to-finish (SF), 156
start-to-start (SS), 156
subcontract, 610
badgeless organization, 615
change control, 616
classification, 535
contract type
cost plus, 612
firm fixed price, 612
Incentive, 612
selecting, 606
technical services, 613
time and materials, 613
control accounts
impacts on, 609, 613
data analysis, 619
defined, 603
directed changes, 617
EVMS flowdown requirements, 604
impact on RFP, 605
EVMS reviews, 620
factoring budget and earned value, 614
formal reprogramming, 619
integrating
BCWS/PMB, 609
schedule, 608
WBS, 607
inter-divisional work authorization (IDWA), 615
internal replanning, 618
major versus non-major, 603
management reserve (MR), 610–611
price versus fee, 609
risk, 605
schedule milestones, 608
surveillance, 620
time lag (data), 613
undistributed budget (UB), 610–611
VAR, 619
WBS, 610
summary activity, 209
summary level planning package (SLPP), 521
surveillance, 620
T
thresholds, 574
time now, 267, 269
to complete performance index (TCPI), 551
total allocated budget (TAB), 524
total float (TF), 166, 169
analysis, 295, 297
and SPI, 555
directed date impact, 310–311
out of sequence logic method impact, 276
traceability
estimate, 453
historical, 455
vertical, 455
schedule
achieving, 252
historical, 252, 285
horizontal, 251, 365
vertical, 251, 363
work scope, 365
U
undistributed budget (UB), 523
log, 590
subcontract, 610–611
usage variance (UV), 558
V
variance, 298
analysis, 573
at completion, 546
cost, 483, 546
duration, 298
labor cost, 558
material, 558
price, 558
rate, 558
schedule, 303, 483, 546
schedule converted to time, 547
schedule start, 298
thresholds, 574
usage, 558
variance analysis report (VAR), 549, 577
approval, 580
corrective action plan, 579
describing the problem, 578
EAC justification, 580
impact, 579
subcontract, 619
variance at completion (VAC), 546

W
what if schedule, 285, 287
work authorization, 525, 527
  inter-divisional, 615
  requirements, 526
work breakdown structure (WBS), 610
  and work authorization, 527
  contract, 57
  defined, 47
  development considerations, 48, 54
dictionary, 53, 590
dictionary example, 54
examples, 48–51
IMP/IMS cross reference, 207
integrating subcontract, 607
intersection with OBS, 91
level of detail, 48
role in estimating, 391
work scope crosscheck, 57
work definition
  process, 45
work package, 499–500, 523
  characteristics, 499
  examples, 501
  level of cost collection, 535
work scope
  and schedule development, 140
  and WBS elements, 47
  and work authorization, 527
  defined, 45
  traceability, 365
  verification, 57
work team
  advantages, 111, 113
  alignment examples, 114
  application examples, 116
  defined, 111
  lead role, 119
work-around plan
  strategies, 287
About the Author

Mr. Gary C. Humphreys has over 35 years of program management experience in both government and commercial environments, specializing in earned value management systems (EVMS) design, development, and implementation. He was the first US Army Team Director to conduct an EVMS Tri-Service Demonstration. As both a Team Member and Team Director, he has assisted, evaluated, and directed review teams leading to successful system acceptance.

He has developed a successful consulting practice operating out of Orange, California. As the premier consultant in this field he has provided assistance in all phases of project management to over 800 clients from aerospace firms to utility companies, England's Inland Revenue Service (IRS), and shipbuilding companies in North America, Australia, and Europe. Within the industry, no one has performed more on-site earned value cost/schedule performance work.

He was elected to the Nine Man Committee for Increasing the Cost Effectiveness of earned value and led the Fifteen Man Industry Committee to modify traditional documentation and interpretation of earned value to be more compatible with efficient, economical production management control techniques. As a member of the Integrated Program Management Initiative Joint Team, Mr. Humphreys received the DOD's highest acquisition award, the 1998 David Packard Excellence in Acquisition Award. He is also a recipient of the Whitey H. Driessnack Award for Outstanding Contributions to the Advancement of Performance Management.

He has served as Vice-Chair and Chair of the National Defense Industrial Association (NDIA) Program Management Systems Subcommittee (PMSC). As a direct result of his tenure as Chair, he took a fledgling committee and developed it into an influential, policy impacting committee with membership growing to over one hundred people. He was also instrumental in opening the lines of communication between the DOD's Performance Measurement Joint Executive Group (PMJEG) and industry by establishing the first dialogue interchange meetings between the two groups. It was through the NDIA PMSC that he orchestrated the first ever survey on EVMS. As a direct result of this survey's findings, the US Government conducted their own survey. These two independent surveys formed the genesis for subsequent revisions to numerous guides and reference material on EVMS.

Under his leadership, the Performance Management Association (PMA) (now the Project Management Institute's College of Performance Management) achieved importance as a policy-influencing group. He initiated international Chapters in Australia and new US Chapters. He served as leader of the Total Quality Management (TQM) Process Action Team (PAT) for streamlining business system descriptions for performance measurement and management applications.

He has been a guest and keynote speaker on a variety of performance measurement related subjects at the Air Force Institute of Technology (AFIT), Association for the Advancement of Cost Engineering International (AACE International), Certified Public Accountants (CPA) Government Contracts Conference, Defense Acquisition University (DAU), National Computer Conference (NCC) of American Federation of Information Processing Societies (AFIPS), PMI, CPM National and International Chapter meetings, and numerous software user groups.

Mr. Humphreys is a graduate of the University of California at Berkeley, with a Masters Degree in Business Administration from the University of Southern California.

He authored the first edition of Project Management Using Earned Value published in 2002. He was a co-author of Project and Production Scheduling, published in 1987. He has also written numerous articles on subjects related to project management and earned value.