"A SEMINAL AND HIGHLY INNOVATIVE BOOK,... A LANDMARK."

Professor Emeritus, Electrical Engineering and

FOR TRUSTWORTHY

TOOLS, TECHNIQUES, AND METHODOLOGY OF DEVELOPING ROBUST SOFTWARE

BIJAY K. JAYASWAL PETER C. PATTON

Contents

Foreword	XXV
Preface	xxvii
Acknowledgments	xxxiii
About the Authors	XXXV
PART I CONTEMPORARY SOFTWARE DEVELOPMENT PROCESS, THEIR SHORTCOMINGS, AND THE CHALLENGE OF TRUSTWORTHY SOFTWARE	
CHAPTER 1 Software Development Methodology Today	3
Software Development: The Need for a New Paradigm	5
Sidebar 1.1: Computer Complexity	7
Software Development Strategies and Life-Cycle Models	8
Build-and-Fix Model	10
Waterfall Model	11
Rapid Prototyping Model	12
Incremental Model	13
Extreme Programming	14
Spiral Model	16
Object-Oriented Programming	17
Iterative Development or Evolutionary Model	19
Comparison of Various Life-Cycle Models	20
Software Process Improvement	20
Rational Unified Process	21
Capability Maturity Model	22
ISO 9000-3 Software Development Guidance Standard Comparison of RUP, CMM, and ISO 9000	23 26

ADR Method	27
Seven Components of the Robust Software Development Process	27
Robust Software Development Model	29
Sidebar 1.2: Mission-Critical Aircraft Control Software	29
Key Points	30
Additional Resources	31
Internet Exercises	31
Review Questions	31
Discussion Questions and Projects	32
Endnotes	32
CHAPTER 2 The Challenge of Trustworthy Software:	
Robust Design in Software Context	35
Software Reliability: Myth and Reality	37
Similarities and Differences Between Software and Manufactured Produ	icts 37
Comparing Software and Hardware Reliability	39
Causes of Software Unreliability	41
Limitations of Traditional Quality Control Systems	43
Japanese Quality Management Systems and the Taguchi Approach	43
Sidebar 2.1: The Life and Times of Dr. Genichi Taguchi	43
Sidebar 2.2: Quality Engineering Methodology at a Glance	45
Sidebar 2.3: Taguchi on Taguchi Methods	46
Sidebar 2.4: The Essence of Denting's 14 Points	48
The Nitty-Gritty of Taguchi Methods for Robust Design	51
The Concept of Signal-to-Noise Ratio	52
The Concept of Quality Loss Function	53
The Concept of Robust Design The Challenge of Software Reliability: Design for Trustworthy Software	55 56
A Robust Software Development Model: DFTS Process in Practice	61
Key Points	63
Additional Resources	65
Internet Exercises	
	65
Review Questions	66
Discussion Questions and Projects	67
Endnotes	67

CHAPTER 3 Software Quality Metrics	69	
Measuring Software Quality	71	
Classic Software Quality Metrics	71	
Total Quality Management	73	
Generic Software Quality Measures	74	
Metrics Methodology	74	
In-Process Quality Metrics for Software Testing	76	
Software Complexity Metrics	77	
Software Science	78	
Cyclomatic Complexity	79	
Function Point Metrics	80	
Availability and Customer Satisfaction Metrics	82	
Sidebar 3.1: A Software Urban Legend	83	
Current Metrics and Models Technology	84	
New Metrics for Architectural Design and Assessment	86	
Common Architectural Design Problems	87	
Pattern Metrics in OOAD	89	
Key Points	90	
Additional Resources	91	
Internet Exercises	91	
Review Questions	91	
Discussion Questions and Projects	92	
Endnotes	92	
CHAPTER 4 Financial Perspectives on Trustworthy Software	95	
Why DFTS Entails Different Financial Analyses	97	
Cost and Quality: Then and Now	98	
Cost of Software Quality	102	
Benefits of Cost-of-Quality Analysis	102	
Cost of Quality Tasks	103	
Classification of Cost of Software Quality	105 109	
Establishing a CoSQ Reporting System		
Payback from Investment in Quality		
Value of CoSQ Analysis	117	
Pitfalls of a CoSQ Program Cost of Software Overling Over the Life Cycle	118 118	
Cost of Software Quality Over the Life Cycle	118	

CoSQ and Activity-Based Costing ABC in a Software Organization Starting ABC in a Software Organization Benefits of ABC Sidebar 4.1: ABC for Service Industries Quality Loss Function in Software Pinancial Evaluation of a DFTS Investment Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative 130 Key Points Additional Resources 134 Internet Exercises 134 Review Questions 135 Problems 136 Endnotes 137 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 3: Recognizing Management Awareness and Buy-in 144 Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure Step 9: Creating an Appropriate Reward System 174
Starting ABC in a Software Organization Benefits of ABC Sidebar 4.1: ABC for Service Industries Quality Loss Function in Software Quality Loss Function in Software 128 Financial Evaluation of a DFTS Investment 129 Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative 130 Key Points 132 Additional Resources 134 Internet Exercises 134 Review Questions 135 Problems 136 Endnotes 137 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment 147 Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication 172
Benefits of ABC Sidebar 4.1: ABC for Service Industries Quality Loss Function in Software Financial Evaluation of a DFTS Investment Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative Mey Points Additional Resources Internet Exercises 134 Internet Exercises 134 Review Questions Discussion Questions Problems Endnotes CHAPTER 5 Organizational Infrastructure and Leadership for DFTS Organizational Challenges of a DFTS Deployment DFTS Implementation Framework Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative Step 3: Recognizing Potential Pitfalls of a DFTS Initiative Step 4: Laying Foundations for a Quality-Focused Enterprise Step 5: Building the Organizational Infrastructure Step 6: Understanding the Roles of the Key Players Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication 172
Sidebar 4.1: ABC for Service Industries Quality Loss Function in Software Financial Evaluation of a DFTS Investment Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative Key Points Additional Resources Internet Exercises Internet Exerci
Quality Loss Function in Software128Financial Evaluation of a DFTS Investment129Metrics for DFTS Evaluation130Establishing a Financial Evaluation Framework for a DFTS Initiative130Key Points132Additional Resources134Internet Exercises134Review Questions135Discussion Questions135Problems136Endnotes138CHAPTER 5 Organizational Infrastructure and Leadership for DFTS139Organizational Challenges of a DFTS Deployment141DFTS Implementation Framework141Step 1: Creating Management Awareness and Buy-in144Step 2: Communicating Top Management's Consensus and Commitment147Step 3: Recognizing Potential Pitfalls of a DFTS Initiative147Sidebar 5.1: Virtuous Teaching Cycle and TPOV156Step 4: Laying Foundations for a Quality-Focused Enterprise157Step 5: Building the Organizational Infrastructure160Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Financial Evaluation of a DFTS Investment Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative 130 Key Points 132 Additional Resources 134 Internet Exercises 134 Review Questions 135 Problems 136 Endnotes 137 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFT'S Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication 172
Metrics for DFTS Evaluation Establishing a Financial Evaluation Framework for a DFTS Initiative 130 Key Points 132 Additional Resources 134 Internet Exercises 134 Review Questions 135 Problems 136 Endnotes 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication
Establishing a Financial Evaluation Framework for a DFTS Initiative Key Points Additional Resources 134 Internet Exercises 134 Review Questions 135 Problems 136 Endnotes 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication
Key Points132Additional Resources134Internet Exercises134Review Questions134Discussion Questions135Problems136Endnotes138CHAPTER 5 Organizational Infrastructure and Leadership for DFTS139Organizational Challenges of a DFTS Deployment141DFTS Implementation Framework141Step 1: Creating Management Awareness and Buy-in144Step 2: Communicating Top Management's Consensus and Commitment147Step 3: Recognizing Potential Pitfalls of a DFTS Initiative147Sidebar 5.1: Virtuous Teaching Cycle and TPOV156Step 4: Laying Foundations for a Quality-Focused Enterprise157Step 5: Building the Organizational Infrastructure160Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Additional Resources Internet Exercises Internet Intern
Internet Exercises Review Questions 134 Discussion Questions 135 Problems 136 Endnotes 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication
Review Questions Discussion Questions 135 Problems 136 Endnotes 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication
Discussion Questions Problems 136 Endnotes 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication
Problems 136 Endnotes 138 CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in 144 Step 2: Communicating Top Management's Consensus and Commitment 147 Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication 172
CHAPTER 5 Organizational Infrastructure and Leadership for DFTS 139 Organizational Challenges of a DFTS Deployment 141 DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in 144 Step 2: Communicating Top Management's Consensus and Commitment 147 Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication 172
CHAPTER 5 Organizational Infrastructure and Leadership for DFTS Organizational Challenges of a DFTS Deployment DFTS Implementation Framework 141 Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise 5: Building the Organizational Infrastructure Step 6: Understanding the Roles of the Key Players Step 7: Designing a Supportive Organizational Structure Step 8: Establishing Effective Communication 172
Organizational Challenges of a DFTS Deployment DFTS Implementation Framework Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise Step 5: Building the Organizational Infrastructure Step 6: Understanding the Roles of the Key Players Step 7: Designing a Supportive Organizational Structure Step 8: Establishing Effective Communication 172
Organizational Challenges of a DFTS Deployment DFTS Implementation Framework Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise Step 5: Building the Organizational Infrastructure Step 6: Understanding the Roles of the Key Players Step 7: Designing a Supportive Organizational Structure Step 8: Establishing Effective Communication 172
DFTS Implementation Framework Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise Step 5: Building the Organizational Infrastructure Step 6: Understanding the Roles of the Key Players Step 7: Designing a Supportive Organizational Structure Step 8: Establishing Effective Communication 148 149 140 147 147 148 149 149 149 140 140 147 140 140 140 141 141
Step 1: Creating Management Awareness and Buy-in Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure Step 6: Understanding the Roles of the Key Players Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication
Step 2: Communicating Top Management's Consensus and Commitment Step 3: Recognizing Potential Pitfalls of a DFTS Initiative 147 Sidebar 5.1: Virtuous Teaching Cycle and TPOV 156 Step 4: Laying Foundations for a Quality-Focused Enterprise 157 Step 5: Building the Organizational Infrastructure 160 Step 6: Understanding the Roles of the Key Players 161 Step 7: Designing a Supportive Organizational Structure 170 Step 8: Establishing Effective Communication 172
Step 2: Communicating Top Management's Consensus and Commitment147Step 3: Recognizing Potential Pitfalls of a DFTS Initiative147Sidebar 5.1: Virtuous Teaching Cycle and TPOV156Step 4: Laying Foundations for a Quality-Focused Enterprise157Step 5: Building the Organizational Infrastructure160Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Sidebar 5.1: Virtuous Teaching Cycle and TPOV156Step 4: Laying Foundations for a Quality-Focused Enterprise157Step 5: Building the Organizational Infrastructure160Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Step 4: Laying Foundations for a Quality-Focused Enterprise157Step 5: Building the Organizational Infrastructure160Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Step 5: Building the Organizational Infrastructure160Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Step 6: Understanding the Roles of the Key Players161Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Step 7: Designing a Supportive Organizational Structure170Step 8: Establishing Effective Communication172
Step 8: Establishing Effective Communication 172
Sten W. Creating an Annionriate Respond System
· · · · · · · · · · · · · · · · · · ·
Step 10: Establishing Cost of Software Quality Step 11: Planning and Launching Organization-Wide Learning 176
Step 11: Planning and Launching Organization-Wide Learning 176 Step 12: Implementing the DFTS Model 177
Step 12: Implementing the DF13 Model Step 13: Monitoring and Feedback for Learning and Improvement 180
Step 14: Freezing the Improvements and Gains 180
Step 15: Integrating and Expanding the Initiative 181

Putting It All Together	181
Key Points	182
Additional Resources	186
Internet Exercises	186
Review Questions	187
Discussion Questions and Projects	188
Endnotes	189
PART II TOOLS AND TECHNIQUES OF DESIGN FOR TRUSTWORTHY SOFTWARE	
CHAPTER 6 The Seven Basic (B7) Tools of Quality	193
The Seven Basic (B7) Tools	196
Sidebar 6.1: Kaoru Ishikawa: Developing a SpecificallyJapanese Quality Strategy	198
B7 in a DFTS Context	200
Other DFTS Tools, Techniques, and Methodologies	201
Flowcharts	202
High-Level Flowcharts	204
Detailed Flowcharts	204
Swim Lane Flowcharts	205
Pareto Charts	205
Cause-and-Effect Diagrams	206
Creating Cause-and-Effect-Diagrams to Identify Causes Cause-and-Effect-Diagrams for Process Classification	208 210
Scatter Diagrams	210
Check Sheets	214
Histograms	215
Determining the Distribution Pattern	216
Determining Whether Specifications Are Satisfied	217
Comparing Data by Stratifying	217
Graphs	218
Control Charts	219
Key Points	222
Additional Resources	223
Review Questions	223
Discussion Questions	224

225

Endnotes

CHAPTER 7	The 7 MP Tools: Analyzing and Interpreting Qualitative	
	and Verbal Data	227
The N7 and 7	MP Tools	230
Typical Applica	ations of 7 MP Tools	231
Affinity Diagra	m	234
Interrelationshi	p Diagraph (I.D.)	238
Tree Diagram		240
Prioritization N	1atrices	244
Matrix Diagrar	n ·	244
Process Decisio	n Program Chart (PDPC)	245
Activity Netwo	rk Diagram	246
Behavioral Skil	ls for 7 MP Tools	247
Key Points		248
Additional Res	ources	249
Review Question	ons	249
Discussion Qu	estions and Projects	250
Endnotes	,	250
CHAPTER 8	The Analytic Hierarchy Process	253
Prioritization,	Complexity, and the Analytic Hierarchy Process	255
Multiobjective	Decision-Making and AHP	256
Terminolog	<i>y</i>	258
Structuring	an Objectives Hierarchy	258
Decision Hi	· · · · · · · · · · · · · · · · · · ·	261
•	: MIS Director's IT Dilemma	261
,	Solution Using Expert Choice	262
1	nstorm and Construct a Hierarchical Model of the Problem	263
•	ive Ratio Scale Priorities for the Objectives	264
_	ive Priorities for the Alternatives with Respect to Each Objective	267 273
Step 4: Synt	nesis as to AHP with Manual Calculations	276
	e Solution Method 1	276
Approximat	e Solution Method 2: Brassard's Full Analytical Criteria Method for	
Prioritizatio	n	284

Conclusion	289
Key Points	289
Additional Resources	290
Internet Exercises	290
Review Questions	290
Discussion Questions and Projects	291
Problems	292
Problem 1: Managing Complexity in System Conversion	292
Problem 2: Managing Software Complexity in a High-TechStart-up Enterprise	294
Problem 3: Complexity in Patient Record Systems	296
Problem 4: Oil Well Drilling Decision System	297
Problem 5: The ROI Issue	299
Problem 6: An Abstract Complexity Analysis Problem 7: Sensitivity to Complexity	299 300
Endnotes	300
CHAPTER 9 Complexity, Mistakes, and Poka Yoke in Software	
Development Processes	303
Poka Yoke as a Quality Control System	305
Principles of Poka Yoke	306
Causes of Defects: Variation, Mistakes, and Complexities	307
Situations in Which Poka Yoke Works Well	309
Mistakes as Causes of Defects	310
Controlling Complexity in Software Development	312
Mistakes, Inspection Methods, and Poka Yoke	316
Deploying a Poka Yoke System	317
Identifying a Poka Yoke Solution	321
Key Points	322
Additional Resources	324
Internet Exercises	325
Review Questions	325
Discussion Questions and Projects	326
Endnotes	326
	220

CHAPTER 10	5S for Intelligent Housekeeping in Software Development	329
5S: A Giant Step	Toward a Productive Workplace Environment	331
	Phases of the 58 System	332
	ng/Cleaning Up	332
	ghtening/Orderliness	332
Phase 3: Shine		333
Phase 4: Stand		333
Phase 5: Susta	•	333
*	nd the DFTS Process	334
Sidebar 10.1: Fro	om 5S to the Lean DFTS Process	335
Overcoming Res	stance	338
Implementing 58		339
Step 1: Manag	gement Buy-in	340
Step 2: Trainir	g and Implementation	340
	a Reward System	340
	-up and Continuous Improvement	340
Key Points		341
Additional Resou		342
Internet Exercises		342
Review Question	S	343
Discussion Questions and Projects		343
Endnotes		
CHAPTER 11	Understanding Customer Needs: Software QFD and	
	the Voice of the Customer	345
QFD: Origin and	l Introduction	347
What's Differe	nt about QFD as a Quality System?	348
The History o		350
,	f Software QFD	350
	FD and Why Do We Need It?	352
A Focus on Priority		
QFD Defined		
QFD Deployments The Four-Phase Model of QFD		
	C -	357
THE HOUSE O	f Quality" Matrix	359

Problems with Traditional QFD Applied to Software	363
Traditional QFD Failures	363
"The Matrix Is Too Big"	364
"It Takes Too Long"	365
"We Knew That Already"	365
Modern QFD for Software	367
Blitz QFD	368
The Seven Management and Planning (7 MP) Tools	368
Customer Satisfaction and Value	369
The Blitz QFD Process	370
Step 1: Key Project Goal	371
Step 2: Key Customer Segment	371
Step 3: Key Process Steps	372
Step 4: Go to Gemba	372
Step 5: What Are the Customer Needs?	374
Step 6: Structure the Customer Needs	377
Step 7: Analyze Customer Needs Structure	378
Step 8: Prioritize the Customer Needs	378
Step 9: Deploy Prioritized Customer Needs	380
Downstream Deployments: Analyze (Only) Important Relationships in Detail	382
The "House of Quality" and Beyond	383
Six Sigma Projects	385
Follow-Up: Apply, Evolve, and Improve the Process	385
Rapid Development	385
Schedule Deployment with Critical Chain Project Management	386
Implementing Software QFD	386
The People Side of QFD	386
QFD Challenges and Pitfalls	387
How to Implement Software QFD	390
Conclusion	391
Modern QFD in the DFTS Process	391
Key Points	393
Additional Resources	394
Internet Exercises	395
Review Questions	396
Discussion Questions	397
Endnotes	399
About the Author	404

CHAPTER 12	Creativity and Innovation in the Software Design TRIZ and Pugh Concept Selection Methodology	Process: 405
The Need for Ci	reativity in DFTS	407
Creativity and T	RIZ	407
Sidebar 12.1: W	hat Is Serendipity?	408
Sidebar 12.2: Be	ing There When the Page Was Blank	411
TRIZ in Softwar	re Development	411
Sidebar 12.3: Lin	ngua Latina Non Mortus Est	412
TRIZ, QFD, and	d Taguchi Methods	419
Brainstorming		421
Pugh Concept S	election Methodology	423
Software as Intel	lectual Property	425
Sidebar 12.4: A	Picture Is Worth	427
Key Points		428
Additional Resou	urces	428
Internet Exercise	es	428
Review Question	ns	429
Discussion Ques	ctions and Projects	429
Endnotes		429
CHAPTER 13	Risk Assessment and Failure Modes and Effects Analysis in Software	431
FMEA: Failure N	Modes and Effects Analysis	433
Upstream Applie	cation of FMEA	437
Software Failure	Software Failure Tree Analysis	
Software Failure	Software Failure Modes and Their Sources	
Risk Assignment and Evaluation at Each Stage of DFTS		445
Key Points		446
Additional Resor	urces	447
Internet Exercise	es	447
Review Question	ns	447
Discussion Ques	stions and Projects	447
Endnotes		448

CHAPTER 14 Object and Component Technologies and Other Development Tools	449		
Major Challenges in Enterprise Business Applications	450		
Object-Oriented Analysis, Design, and Programming			
Sidebar 14.1: The Birth of Object-Oriented Programming	451		
Sidebar 14.2: The Power of Java Middleware	458		
Component-Based Software Development Technology	459		
Extreme Programming for Productivity	462		
N-Version Programming for Reliability	463		
Advantages of NVP	464		
Disadvantages of NVP	465		
Modern Programming Environments	465		
Trends in Computer Programming Automation	469		
Key Points	472		
Additional Resources	472		
Internet Exercises	472		
Review Questions	473		
Discussion Questions and Projects	473		
Endnotes	473		
PART III DESIGNING FOR TRUSTWORTHY SOFTWARE			
CHAPTER 15 Quality Measures and Statistical Methods for			
Trustworthy Software	479		
Trustworthy Software	481		
Microsoft's Trustworthy Computing Initiative	482		
Statistical Process Control for Software Development Processes			
Statistical Methods for Software Architects	491		
Key Points	494		
Additional Resources	495		
Internet Exercises			
Review Questions			
Discussion Questions and Projects	496		
Problems	496		
Endnotes	496		

CHAPTER 16 Robust Software in Context	499
The Software Specification Process	501
Sidebar 16.1: A Precise Functional Specification	503
What Is Robust Software?	504
Requirements for Software to Be Robust	505
Sidebar 16.2: Getting the End User's Input	506
Specifying Software Robustness	506
Sidebar 16.3: An Example of Parameter Design	508
Key Points	508
Additional Resources	509
Internet Exercises	509
Review Questions	509
Discussion Questions and Projects	509
Problems	510
Endnotes	510
CHAPTER 17 Taguchi Methods and Optimization for Robust Software	511
Taguchi Methods for Robust Software Design	513
An Example from Engineering Design	517
An Example from Software Design and Development	521
Orthogonal Matrices for Taguchi Parameter Design Experiments	526
Applications to the Design of Trustworthy Software	529
Key Points	529
Additional Resources	530
Internet Exercises	530
Review Questions	530
Discussion Questions	530
Problems	531
Endnotes	531

CHAPTER 18	Verification, Validation, Testing, and Evaluation for Trustworthiness	533
Continuing the I		535
Continuing the Development Cycle Sidebar 18.1: An Urban Legend About Business Software		536
Verification	Cibali Degend Moode Business Software	537
	Taguchi Methods for RTOS Design Verification	537
Validation	Tugues in the object remaining	541
	Taguchi Methods for Software Validation	541
•	Testing and Evaluation	
Sidebar 18.2: Testing and Debugging Anomalies		544 545
Key Points	0 100 0	549
Additional Resou	ırces	550
Internet Exercises		550
Review Question	S	550
~	tions and Projects	550
Problems	,	551
Endnotes		551
CHAPTER 19	Integration, Extension, and Maintenance for Trustworthiness	553
Completing the	Development Cycle	555
Integration	bevelopment Gyele	555
•	e Supermarine Spitfire	556
Extension		
	Extending the Capability of an Electronic Warfare System	556 557
Maintenance	<i>g g</i>	558
	Field Maintenance of Software Systems	559
•	aintaining Sophisticated Software Functionality Out of Existence	560
Key Points	7	561
Additional Resou	ırces	561
Internet Exercise		562
Review Questions		562
Discussion Questions and Projects		562
Problems		562
Endnotes		563

PART IV PUTTING IT ALL TOGETHER: DEPLOYMENT OF A DFTS PROGRAM

CHAPTER 20 Organizational Preparedness for DFTS	567	
Time to Ponder	569	
Case Study 20.1: Striving for a Perfect Production Process		
Case Study 20.2: Institutionalizing Six Sigma at GE		
Leadership Challenges for Transformational Initiatives	577	
Assessing Key Organizational Elements		
Creating Leadership Commitment		
Understanding the Leadership Role		
Assessing Strategic Linkages		
Ensuring Organization-Wide Participation	580	
Understanding the Need for Customer Focus	581	
Assessing Current Quality Management Capability	582	
Key Points	583	
Additional Resources	584	
Internet Exercises	585	
Review Questions	585	
Discussion Questions and Projects	585	
Endnotes	586	
CHAPTER 21 Launching a DFTS Initiative	587	
DFTS and the PICS Framework		
Plan		
Implement	592	
Step 11: Launching Organization-Wide Learning	592	
Designing Learning Curricula: Customization and Differentiation	593	
Training Support Personnel	593	
Step 12: Implementing DFTS Technology: Learning and Application Process	595	
Control	600	
Step 13: Feedback Control Systems	603	
Case Study 21.1: GE's Operating System for Continual Learning and Enrichment		
Project Management	610	
Secure	611	
Step 14: Freezing the Improvements and Gains	611	
Step 15: Integrating and Expanding the Initiative	612	

Case Study 21.2: Quality Initiatives and Their Integration at TCS		618
Application in St	Application in Small Software Firms and e-Cottages	
What's Next?		
Key Points	Key Points	
Additional Resou	ırces	623
Internet Exercise	\$	623
Review Question	ns	624
Discussion Questions		625
Endnotes		625
PART V Six 6	Case Studies	
CHAPTER 22	Cost of Software Quality (CoSQ) at Raytheon's Elect	ronic
	Systems (RES) Group	633
Introduction		634
RES and Its Imp	provement Program	634
Cost of Software	Quality	635
RES's CoSQ	Model	635
CoSQ Data C	- Gathering	636
Experiences and	Lessons Learned	636
-	Usage Lessons	636
~	SQ Data to Understand the Impact of Improvement	637
CoSQ Costs a		640
	ration of CoSQ Tracking	641
Case Study Impl	acations	641
Endnotes		642
CHAPTER 23	Information Technology Portfolio Alignment	643
Part One-—The	Challenge	644
	ses of an Iterative Process	645
	ubjectivity, and Quality	648
Part Two-A New, Rational Approach		649
Step 1: Design		649
Step 2: Structuring Complexity—Focusing on Objectives		650 651
Step 3: Measurement		
Step 4: Synthesis		656 657
Step 5: Optimization		

Risk		660
Extensions		662
Summary		664
Endnote		664
Enumote		00-1
CHAPTER 24	Defining Customer Needs for Brand-New Products:	
	QFD for Unprecedented Software	665
Introduction		667
Definition of Value		667
Why Not As	k?	668
Unprecedent	ed Products	669
Defining Brand	-New Needs	669
Methods for	Defining Customer Needs	669
Tools		674
QFD's Seven Management and Planning (7MP) Tools		675
Sidebar 24.1: W	That Is the Theory of Constraints (TOC)?	676
TOC's Thin	king Processes	677
Last Steps		678
Marketing B	rand-New Products	678
Layers of Resistance		679
Conclusion		682
Acknowledgme	nts	682
References		682
About the Auth	or	684
CHAPTER 25	Jurassic QFD: Integrating Service and Product Quality	
	Function Deployment	685
Company Profi	le of MD Robotics	686
Why QFD?		687
History of Q	PFD	687
Kano's Requirements		
Triceratops Encounter at Universal Studios Florida Island of Adventure		
QFD Template		
Voice of Customer Analysis		
Emotion Deployment		

Body Deployment		
Engineering Requirements Deployment		
Summary		
About the Authors	703	
References	704	
CHAPTER 26 Project QFD: Managing Software Development		
Projects Better with Blitz QFD	707	
Introduction	709	
Failure		
Partial Success		
QFD Defined	710	
Starting Right	710 710	
Problems with New Development		
Incoherent Development Is Inefficient		
Coherent Development Is Efficient	713	
Focus on Value with Project QFD	714	
Seven Steps to Better Projects	715 7 2 5	
Summary		
Acknowledgments		
References		
About the Author	728	
CHAPTER 27 QFD 2000: Integrating QFD and Other Quality Methods		
to Improve the New-Product Development Process	729	
Demand for New Products	730	
Quality and New-Product Development	730	
Modern Quality Tools	732	
New-Product Development Process	734	
Resources for QFD and Other Quality Methods	737	
Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP)		
Balanced Scorecard		
Blitz QFD		
Conjoint Analysis		
Consumer Encounters		
Customer Integrated Decision Making (CIDM)		

de Bono	738
Deming	738
Gemba Visit/Voice of Customer Analysis	738
Hoshin Planning	739
Kano Model	739
Kansei Engineering	739
Lead User Research	739
Lean Manufacturing	740
New Lanchester Strategy	740
Neural Linguistic Programming (NLP)	740
Project Management	740
Pugh Concept Selection	740
QFD (Comprehensive)	740
Reliability	741
Seeds to Needs QFD	741
Seven Management and Planning (7 MP) Tools	741
Seven Product Planning (7PP) Tools	741
Seven Quality Control (7QC) Tools	741
Six Sigma, SPC	742
Software Engineering	742
Stage-Gate	742
Strategic Information Systems (SIS)	742
Supply Chain Management	742
Taguchi Methods	742
Theory of Constraints	742
Total Quality Management (TQM)	743
TRIZ	743
Value Engineering	743
About the Author	743
References	744
Glossary of Technical Terms	745
Name Index	753
Index	759