

CONTENTS

Prefacexiii

PART I Six Sigma Implementation and Management

CHAPTER 1 Building the Responsive Six Sigma Organization 3

What Is Six Sigma? 3

Why Six Sigma? 4

The Six Sigma Philosophy 6

Six Sigma Versus Traditional Three Sigma Performance 8

The Change Imperative 12

Implementing Six Sigma 17

Timetable 18

Infrastructure 21

Integrating Six Sigma and Related Initiatives 38

Deployment to the Supply Chain 52

Communications and Awareness 54

CHAPTER 2 Recognizing and Capitalizing on Opportunity 63

Methods for Collecting Customer Data 63

Surveys 64

Focus Groups 73

Operational Feedback Systems 74

Cost of Poor Quality 77

Cost of Quality Examples 80

Quality Cost Bases 83

Benchmarking 84

The Benchmarking Process 84

Getting Started with Benchmarking 85

Why Benchmarking Efforts Fail 87

The Benefits of Benchmarking 88

	<i>Some Dangers of Benchmarking</i>	89
	Innovation	89
	<i>Kano Model</i>	90
	<i>Quality Function Deployment</i>	91
	<i>Translating Customer Demands</i>	95
	<i>Creative Destruction</i>	103
	Strategic Planning	108
	<i>Organizational Vision</i>	109
	<i>Strategy Development</i>	111
	<i>Strategic Styles</i>	112
	<i>Possibilities-Based Strategic Decisions</i>	113
	Strategic Development Using Constraint Theory	115
	<i>The Systems Approach</i>	116
	<i>Basic Constraint Management Principles and Concepts</i>	119
	<i>Tools of Constraint Management</i>	128
	<i>Constraint Management Measurements</i>	140
	<i>Summary and Conclusion</i>	145
CHAPTER 3	Data-Driven Management	147
	Attributes of Good Metrics	147
	<i>Measuring Causes and Effects</i>	149
	The Balanced Scorecard	151
	<i>Translating the Vision</i>	153
	<i>Communicating and Linking</i>	161
	<i>Business Planning</i>	164
	<i>Feedback and Learning</i>	168
CHAPTER 4	Maximizing Resources	179
	Choosing the Right Projects	179
	<i>Types of Projects</i>	180
	<i>Analyzing Project Candidates</i>	181
	<i>Using Pareto Analysis to Identify Six Sigma</i>	
	<i>Project Candidates</i>	189
	<i>Throughput-Based Project Selection</i>	191
	Ongoing Management Support	197
	<i>Internal Roadblocks</i>	198
	<i>External Roadblocks</i>	199
	<i>Individual Barriers to Change</i>	199

Ineffective Management Support Strategies 200
Effective Management Support Strategies 201
Cross-Functional Collaboration 202
Tracking Six Sigma Project Results 203
 Financial Results Validation 206
 Team Performance Evaluation 206
 Team Recognition and Reward 207
 Lessons-Learned Capture and Replication 209

PART II Six Sigma Tools and Techniques

CHAPTER 5 Project Management Using DMAIC and DMADV 213
DMAIC and DMADV Deployment Models 213
 Project Scheduling 218
 Project Reporting 230
 Project Budgets 232
 Project Records 233
Six Sigma Teams 234
 Team Membership 235
 Team Dynamics Management, Including Conflict Resolution . . . 235
 Stages in Group Development 236
 Member Roles and Responsibilities 238
 Management's Role 240
 Facilitation Techniques 240

CHAPTER 6 The Define Phase 245
Project Charters 245
Project Decomposition 247
 Work Breakdown Structures 247
 Pareto Analysis 249
Deliverables 250
 Critical to Quality Metrics 251
 Critical to Schedule Metrics 257
 Critical to Cost Metrics 261
Top-Level Process Definition 266
 Process Maps 267
Assembling the Team 267

CHAPTER 7	The Measure Phase	271
	Process Definition	271
	<i>Flowcharts</i>	272
	<i>SIPOC</i>	273
	Metric Definition	277
	<i>Measurement Scales</i>	278
	<i>Discrete and Continuous Data</i>	280
	Process Baseline Estimates	280
	<i>Enumerative and Analytic Studies</i>	282
	<i>Principles of Statistical Process Control</i>	285
	<i>Estimating Process Baselines Using Process Capability Analysis</i> ..	291
CHAPTER 8	Process Behavior Charts	293
	Distributions	293
	<i>Methods of Enumeration</i>	293
	<i>Frequency and Cumulative Distributions</i>	295
	<i>Sampling Distributions</i>	296
	<i>Binomial Distribution</i>	297
	<i>Poisson Distribution</i>	298
	<i>Hypergeometric Distribution</i>	300
	<i>Normal Distribution</i>	302
	<i>Lognormal Distribution</i>	307
	<i>Exponential Distribution</i>	308
	<i>Weibull Distribution</i>	309
	Control Charts for Variables Data	311
	<i>Averages and Ranges Control Charts</i>	311
	<i>Averages and Standard Deviation (Sigma) Control Charts</i>	315
	<i>Control Charts for Individual Measurements (X Charts)</i>	317
	Control Charts for Attributes Data	324
	<i>Control Charts for Proportion Defective (p Charts)</i>	324
	<i>Control Charts for Count of Defectives (np Charts)</i>	328
	<i>Control Charts for Average Occurrences-Per-Unit (u Charts)</i> ..	330
	<i>Control Charts for Counts of Occurrences-Per-Unit (c Charts)</i> ..	334
	Control Chart Selection	337
	<i>Rational Subgroup Sampling</i>	337
	Control Chart Interpretation	342
	<i>Run Tests</i>	347
	Short-Run Statistical Process Control Techniques	350

	<i>Variables Data</i>	350
	<i>Attribute SPC for Small and Short Runs</i>	362
	<i>Summary of Short-Run SPC</i>	369
	SPC Techniques for Automated Manufacturing	369
	<i>Problems with Traditional SPC Techniques</i>	370
	<i>Special and Common Cause Charts</i>	370
	<i>EWMA Common Cause Charts</i>	371
	<i>EWMA Control Charts Versus Individuals Charts</i>	378
	Process Capability Indices	381
	<i>Example of Non-Normal Capability Analysis Using Minitab</i>	386
CHAPTER 9	Measurement Systems Evaluation	393
	Definitions	393
	<i>Measurement System Discrimination</i>	397
	<i>Stability</i>	397
	<i>Bias</i>	399
	<i>Repeatability</i>	400
	<i>Reproducibility</i>	402
	<i>Part-to-Part Variation</i>	405
	Example of Measurement System Analysis Summary	406
	<i>Gage R&R Analysis Using Minitab</i>	407
	Linearity	411
	<i>Linearity Analysis Using Minitab</i>	413
	Attribute Measurement Error Analysis	415
	<i>Operational Definitions</i>	415
	<i>How to Conduct Attribute Inspection Studies</i>	418
	<i>Example of Attribute Inspection Error Analysis</i>	419
	<i>Minitab Attribute Gage R&R Example</i>	422
CHAPTER 10	Analyze Phase	427
	Value Stream Analysis	427
	<i>Value Stream Mapping</i>	431
	<i>Spaghetti Charts</i>	436
	Analyzing the Sources of Variation	437
	<i>Cause and Effect Diagrams</i>	438
	<i>Boxplots</i>	440
	<i>Statistical Inference</i>	442
	<i>Chi-Square, Student's t, and f Distributions</i>	443

	<i>Point and Interval Estimation</i>	448
	<i>Hypothesis Testing</i>	455
	<i>Resampling (Bootstrapping)</i>	462
	Regression and Correlation Analysis	463
	<i>Linear Models</i>	466
	<i>Least-Squares Fit</i>	469
	<i>Correlation Analysis</i>	473
	Designed Experiments	475
	The Traditional Approach Versus Statistically	
	Designed Experiments	475
	<i>Terminology</i>	475
	<i>Design Characteristics</i>	477
	<i>Types of Design</i>	478
	<i>One-Factor ANOVA</i>	480
	<i>Two-Way ANOVA with No Replicates</i>	482
	<i>Two-Way ANOVA with Replicates</i>	483
	<i>Full and Fractional Factorial</i>	485
	<i>Power and Sample Size</i>	494
	<i>Testing Common Assumptions</i>	495
	Analysis of Categorical Data	502
	<i>Making Comparisons Using Chi-Square Tests</i>	502
	<i>Logistic Regression</i>	504
	<i>Binary Logistic Regression</i>	506
	<i>Ordinal Logistic Regression</i>	509
	<i>Nominal Logistic Regression</i>	513
	Non-Parametric Methods	515
CHAPTER 11	The Improve/Design Phase	521
	Using Customer Demands to Make Design and	
	Improvement Decisions	521
	<i>Pugh Concept Selection Method</i>	521
	Lean Techniques for Optimizing Flow	522
	<i>Tools to Help Improve Flow</i>	523
	Using Empirical Model Building to Optimize	526
	<i>Phase 0: Getting Your Bearings</i>	528
	<i>Phase I: The Screening Experiment</i>	529
	<i>Phase II: Steepest Ascent (Descent)</i>	533
	<i>Phase III: The Factorial Experiment</i>	534

	<i>Phase IV: The Composite Design</i>	537
	<i>Phase V: Robust Product and Process Design</i>	541
	Data Mining, Artificial Neural Networks, and Virtual	
	Process Mapping	545
	<i>Example of Neural Net Models</i>	546
	Optimization Using Simulation	549
	<i>Predicting CTQ Performance</i>	550
	<i>Simulation Tools</i>	550
	<i>Random Number Generators</i>	554
	<i>Model Development</i>	558
	<i>Virtual DOE Using Simulation Software</i>	567
	Risk Assessment Tools	569
	<i>Design Review</i>	570
	<i>Fault-Tree Analysis</i>	571
	<i>Safety Analysis</i>	572
	<i>Failure Mode and Effect Analysis</i>	575
	Defining New Performance Standards Using	
	Statistical Tolerancing	578
	<i>Assumptions of Formula</i>	582
	<i>Tolerance Intervals</i>	582
CHAPTER 12	Control/Verify Phase	585
	Validating the New Process or Product Design	585
	Business Process Control Planning	585
	<i>Maintaining Gains</i>	586
	<i>Tools and Techniques Useful for Control Planning</i>	588
	<i>Preparing the Process Control Plan</i>	589
	<i>Process Control Planning for Short and Small Runs</i>	591
	<i>Process Audits</i>	594
	<i>Selecting Process Control Elements</i>	594
	<i>Other Elements of the Process Control Plan</i>	597
APPENDIX 1	Glossary of Basic Statistical Terms	601
APPENDIX 2	Area Under the Standard Normal Curve	607
APPENDIX 3	Critical Values of the <i>t</i>-Distribution	611

APPENDIX 4	Chi-Square Distribution	613
APPENDIX 5	F Distribution ($\alpha = 1\%$)	615
APPENDIX 6	F Distribution ($\alpha = 5\%$)	617
APPENDIX 7	Poisson Probability Sums	619
APPENDIX 8	Tolerance Interval Factors	623
APPENDIX 9	Control Chart Constants	627
APPENDIX 10	Control Chart Equations	629
APPENDIX 11	Table of d_2^* Values	631
APPENDIX 12	Factors for Short Run Control Charts for Individuals, \bar{X}, and R Charts	633
APPENDIX 13	Sample Customer Survey	635
APPENDIX 14	Process σ Levels and Equivalent PPM Quality Levels	637
APPENDIX 15	Black Belt Effectiveness Certification	639
APPENDIX 16	Green Belt Effectiveness Certification	651
APPENDIX 17	AHP Using Microsoft Excel	663
	References	667
	Index	675