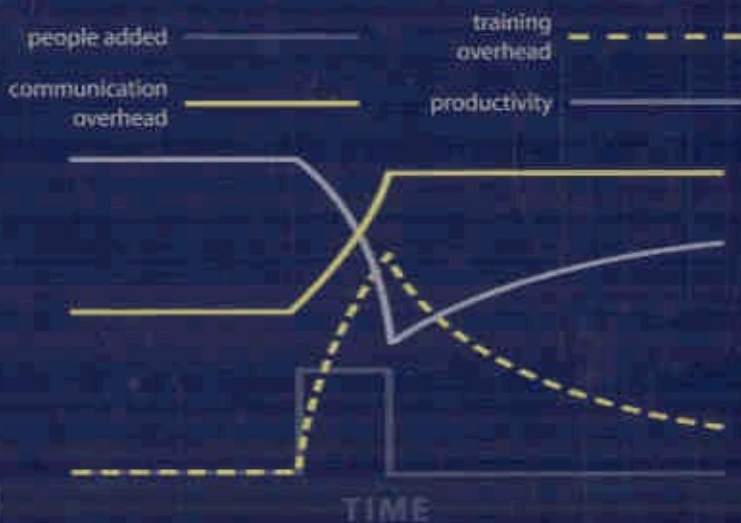


SOFTWARE PROCESS DYNAMICS



WWW.
JAYMADACHY.COM

Raymond J. Madachy

CONTENTS

Foreword	xiii
<i>Barry Boehm</i>	

Preface	xvii
---------	------

PART 1 FUNDAMENTALS

Chapter 1 Introduction and Background	3
1.1 Systems, Processes, Models, and Simulation	6
1.2 Systems Thinking	8
1.2.1 The Fifth Discipline and Common Models	9
1.2.2 Systems Thinking Compared to System Dynamics	9
1.2.3 Weinberg's Systems Thinking	10
1.3 Basic Feedback Systems Concepts Applied to the Software Process	10
1.3.1 Using Simulation Models for Project Feedback	13
1.3.2 System Dynamics Introductory Example	14
1.4 Brooks's Law Example	16
1.4.1 Brooks's Law Model Behavior	19
1.5 Software Process Technology Overview	22
1.5.1 Software Process Modeling	22
1.5.2 Process Lifecycle Models	29
1.5.3 Process Improvement	40
1.6 Challenges for the Software Industry	45
1.7 Major References	47
1.8 Chapter 1 Summary	48
1.9 Exercises	49

Chapter 2	The Modeling Process with System Dynamics	53
2.1	System Dynamics Background	54
2.1.1	Conserved Flows Versus Nonconserved Information	55
2.1.2	The Continuous View Versus Discrete Event Modeling	55
2.1.3	Model Elements and Notations	56
2.1.4	Mathematical Formulation of System Dynamics	56
2.1.5	Using Heuristics	60
2.1.6	Potential Pitfalls	60
2.2	General System Behaviors	61
2.2.1	Goal-Seeking Behavior	61
2.2.2	Information Smoothing	63
2.2.3	Example: Basic Structures for General Behaviors	63
2.3	Modeling Overview	64
2.3.1	An Iterative Process	68
2.3.2	Applying the WinWin Spiral Model	70
2.4	Problem Definition	73
2.4.1	Defining the Purpose	73
2.4.2	Reference Behavior	74
2.4.3	Example: Model Purpose and Reference Behavior	75
2.5	Model Conceptualization	75
2.5.1	Identification of System Boundary	78
2.5.2	Causal Loop Diagrams	79
2.6	Model Formulation and Construction	83
2.6.1	Top-Level Formulation	84
2.6.2	Basic Patterns and Rate Equations	90
2.6.3	Graph and Table Functions	96
2.6.4	Assigning Parameter Values	99
2.6.5	Model Building Principles	101
2.6.6	Model Integration	103
2.6.7	Example: Construction Iterations	104
2.7	Simulation	110
2.7.1	Steady-state Conditions	112
2.7.2	Test Functions	113
2.7.3	Reference Behavior	115
2.8	Model Assessment	116
2.8.1	Model Validation	117
2.8.2	Model Sensitivity Analysis	121
2.8.3	Monte Carlo Analysis	125
2.9	Policy Analysis	126
2.9.1	Policy Parameter Changes	127
2.9.2	Policy Structural Changes	128
2.9.3	Policy Validity and Robustness	129
2.9.4	Policy Suitability and Feasibility	130
2.9.5	Example: Policy Analysis	130
2.10	Continuous Model Improvement	131
2.10.1	Disaggregation	132

2.10.2	Feedback Loops	132
2.10.3	Hypotheses	132
2.10.4	When to Stop?	133
2.10.5	Example: Model Improvement Next Steps	133
2.11	Software Metrics Considerations	134
2.11.1	Data Collection	134
2.11.2	Goal–Question–Metric Framework	135
2.11.3	Integrated Measurement and Simulation	136
2.12	Project Management Considerations	138
2.12.1	Modeling Communication and Team Issues	139
2.12.2	Risk Management of Modeling Projects	140
2.12.3	Modeling Documentation and Presentation	141
2.12.4	Modeling Work Breakdown Structure	142
2.13	Modeling Tools	142
2.14	Major References	145
2.15	Chapter 2 Summary	146
2.15.1	Summary of Modeling Heuristics	148
2.16	Exercises	149
Chapter 3	Model Structures and Behaviors for Software Processes	155
3.1	Introduction	155
3.2	Model Elements	157
3.2.1	Levels (Stocks)	157
3.2.2	Rates (Flows)	159
3.2.3	Auxiliaries	159
3.2.4	Connectors and Feedback Loops	160
3.3	Generic Flow Processes	160
3.3.1	Rate and Level System	160
3.3.2	Flow Chain with Multiple Rates and Levels	161
3.3.3	Compounding Process	162
3.3.4	Draining Process	163
3.3.5	Production Process	163
3.3.6	Adjustment Process	163
3.3.7	Coflow Process	164
3.3.8	Split Flow Process	165
3.3.9	Cyclic Loop	165
3.4	Infrastructures and Behaviors	166
3.4.1	Exponential Growth	166
3.4.2	S-Shaped Growth and S-Curves	167
3.4.3	Delays	169
3.4.4	Balancing Feedback	175
3.4.5	Oscillation	177
3.4.6	Smoothing	180
3.4.7	Production and Rework	182
3.4.8	Integrated Production Structure	183
3.4.9	Personnel Learning Curve	183

3.4.10	Rayleigh Curve Generator	185
3.4.11	Attribute Tracking	186
3.4.12	Attribute Averaging	187
3.4.13	Effort Expenditure Instrumentation	187
3.4.14	Decision Structures	188
3.5	Software Process Chain Infrastructures	192
3.5.1	Software Products	193
3.5.2	Defects	196
3.5.3	People	200
3.6	Major References	203
3.7	Chapter 3 Summary	204
3.8	Exercises	204

PART 2 APPLICATIONS AND FUTURE DIRECTIONS

Introduction to Applications Chapters	211	
Chapter 4 People Applications	217	
4.1	Introduction	217
4.2	Overview of Applications	221
4.3	Project Workforce Modeling	222
4.3.1	Example: Personnel Sector Model	222
4.4	Exhaustion and Burnout	224
4.4.1	Example: Exhaustion Model	224
4.5	Learning	227
4.5.1	Example: Learning Curve Models	231
4.6	Team Composition	234
4.6.1	Example: Assessing Agile Team Size for a Hybrid Process	235
4.7	Other Application Areas	252
4.7.1	Motivation	252
4.7.2	Personnel Hiring and Retention	256
4.7.3	Skills and Capabilities	260
4.7.4	Team Communication	260
4.7.5	Negotiation and Collaboration	261
4.7.6	Simulation for Personnel Training	263
4.8	Major References	265
4.9	Chapter 4 Summary	265
4.10	Exercises	267
Chapter 5 Process and Product Applications	269	
5.1	Introduction	269
5.2	Overview of Applications	273
5.3	Peer Reviews	274
5.3.1	Example: Modeling an Inspection-Based Process	275
5.3.2	Example: Inspection Process Data Calibration	289

5.4	Global Process Feedback (Software Evolution)	291
5.4.1	Example: Software Evolution Progressive and Antiregressive Work	293
5.5	Software Reuse	299
5.5.1	Example: Reuse and Fourth-Generation Languages	301
5.6	Commercial Off-the-Shelf Software (COTS)-Based Systems	309
5.6.1	Example: COTS Glue Code Development and COTS Integration	310
5.6.2	Example: COTS-Lifespan Model	317
5.7	Software Architecting	319
5.7.1	Example: Architecture Development During Inception and Elaboration	319
5.8	Quality and Defects	327
5.8.1	Example: Defect Dynamics	328
5.8.2	Example: Defect Removal Techniques and Orthogonal Defect Classification	330
5.9	Requirements Volatility	333
5.9.1	Example: Software Project Management Simulator	337
5.10	Software Process Improvement	343
5.10.1	Example: Software Process Improvement Model	346
5.10.2	Example: Xerox Adaptation	354
5.11	Major References	362
5.12	Provided Models	363
5.13	Chapter 5 Summary	363
5.14	Exercises	364
Chapter 6	Project and Organization Applications	369
6.1	Introduction	369
6.1.1	Organizational Opportunities for Feedback	371
6.2	Overview of Applications	372
6.3	Integrated Project Modeling	373
6.3.1	Example: Integrated Project Dynamics Model	373
6.4	Software Business Case Analysis	395
6.4.1	Example: Value-Based Product Modeling	396
6.5	Personnel Resource Allocation	411
6.5.1	Example: Resource Allocation Policy and Contention Models	411
6.6	Staffing	416
6.6.1	Example: Rayleigh Manpower Distribution Model	418
6.6.2	Example: Process Concurrence Modeling	423
6.6.3	Integrating Rayleigh Curves, Process Concurrence, and Brooks's Interpretations	441
6.7	Earned Value	442
6.7.2	Example: Earned Value Model	450
6.8	Major References	460
6.9	Provided Models	460

6.10	Chapter 6 Summary	460
6.11	Exercises	462
Chapter 7	Current and Future Directions	469
7.1	Introduction	469
7.2	Simulation Environments and Tools	472
7.2.1	Usability	473
7.2.2	Model Analysis	473
7.2.3	Artificial Intelligence and Knowledge-Based Simulation	474
7.2.4	Networked Simulations	475
7.2.5	Training and Game Playing	475
7.3	Model Structures and Component-Based Model Development	476
7.3.1	Object-Oriented Methods	478
7.3.2	Metamodels	478
7.4	New and Emerging Trends for Applications	479
7.4.1	Distributed Global Development	480
7.4.2	User and People-Oriented Focus	482
7.4.3	Agile and Hybrid Processes	482
7.4.4	Commercial Off-the-Shelf Software	484
7.4.5	Open Source Software Development	486
7.4.6	Personnel Talent Supply and Demand	488
7.5	Model Integration	489
7.5.1	Common Unified Models	489
7.5.2	Related Disciplines and Business Processes	490
7.5.3	Meta-Model Integration	491
7.6	Empirical Research and Theory Building	492
7.6.1	Empirical Data Collection for Simulation Models	493
7.7	Process Mission Control Centers, Analysis, and Training Facilities	494
7.8	Chapter 7 Summary	496
7.9	Exercises	498
Appendix A:	Introduction to Statistics of Simulation	501
A.1	Risk Analysis and Probability	502
A.2	Probability Distributions	503
A.2.1	Interpreting Probability Distributions	505
A.2.2	Measures of Location, Variability and Symmetry	506
A.2.3	Useful Probability Distributions	508
A.3	Monte Carlo Analysis	515
A.3.1	Inverse Transform	515
A.3.2	Example: Monte Carlo Analysis	516
A.4	Analysis of Simulation Input	521
A.4.1	Goodness-of-Fit Tests	521
A.5	Experimental Design	523
A.5.1	Example: Experimental Design and Model Response Surface	524

A.6	Analysis of Simulation Output	525
A.6.1	Confidence Intervals, Sample Size, and Hypothesis Testing	525
A.7	Major References	527
A.8	Appendix A Summary	527
A.9	Exercises	529
Appendix B: Annotated System Dynamics Bibliography		531
Appendix C: Provided Models¹		565
References		571
Index		593