

Contents

List of Contributors	xi
Preface	xiii
Introduction: The Why, What and How of Social Systems Engineering <i>César García-Díaz and Camilo Olaya</i>	1
Part I SOCIAL SYSTEMS ENGINEERING: THE VERY IDEA	11
1 Compromised Exactness and the Rationality of Engineering <i>Steven L. Goldman</i>	13
1.1 Introduction	13
1.2 The Historical Context	14
1.3 Science and Engineering: Distinctive Rationalities	20
1.4 'Compromised Exactness': Design in Engineering	23
1.5 Engineering Social Systems?	26
References	29
2 Uncertainty in the Design and Maintenance of Social Systems <i>William M. Bulleit</i>	31
2.1 Introduction	31
2.2 Uncertainties in Simple and Complicated Engineered Systems	33
2.3 Control Volume and Uncertainty	35
2.4 Engineering Analysis and Uncertainty in Complex Systems	37
2.5 Uncertainty in Social Systems Engineering	39
2.6 Conclusions	42
References	42

3	System Farming	45
	<i>Bruce Edmonds</i>	
3.1	Introduction	45
3.2	Uncertainty, Complexity and Emergence	46
	3.2.1 <i>The Double Complexity of CSS</i>	48
3.3	Science and Engineering Approaches	49
	3.3.1 <i>The Impossibility of a Purely Design-Based Engineering Approach to CSS</i>	51
	3.3.2 <i>Design vs. Adaptation</i>	52
	3.3.3 <i>The Necessity of Strongly Validated Foundations for Design-Based Approaches</i>	53
3.4	Responses to CSS Complexity	54
	3.4.1 <i>Formal Methods</i>	54
	3.4.2 <i>Statistical Approaches</i>	55
	3.4.3 <i>Self-adaptive and Adaptive Systems</i>	57
	3.4.4 <i>Participatory Approaches and Rapid Prototyping</i>	57
3.5	Towards Farming Systems	58
	3.5.1 <i>Reliability from Experience Rather Than Control of Construction</i>	58
	3.5.2 <i>Post-Construction Care Rather Than Prior Effort</i>	58
	3.5.3 <i>Continual Tinkering Rather Than One-Off Effort</i>	59
	3.5.4 <i>Multiple Fallible Mechanisms Rather Than One Reliable Mechanism</i>	59
	3.5.5 <i>Monitoring Rather Than Prediction</i>	59
	3.5.6 <i>Disaster Aversion Rather Than Optimizing Performance</i>	59
	3.5.7 <i>Partial Rather Than Full Understanding</i>	59
	3.5.8 <i>Specific Rather Than Abstract Modelling</i>	60
	3.5.9 <i>Many Models Rather Than One</i>	60
	3.5.10 <i>A Community Rather Than Individual Effort</i>	60
3.6	Conclusion	60
	References	61
4	Policy between Evolution and Engineering	65
	<i>Martin F.G. Schaffernicht</i>	
4.1	Introduction: Individual and Social System	65
4.2	Policy – Concept and Process	67
4.3	Human Actors: Perception, Policy and Action	70
4.4	Artefacts	73
4.5	Engineering and Evolution: From External to Internal Selection	76
4.6	Policy between Cultural Evolution and Engineering	79
4.7	Conclusions and Outlook	82
	Appendix: Brief Overview of the Policy Literature	83
	References	86
5	‘Friend’ versus ‘Electronic Friend’	91
	<i>Joseph C. Pitt</i>	
	References	99

6	Interactive Visualizations for Supporting Decision-Making in Complex Socio-technical Systems	103
	<i>Zhongyuan Yu, Mehrnoosh Oghbaie, Chen Liu, William B. Rouse and Michael J. Pennock</i>	
6.1	Introduction	103
6.2	Policy Flight Simulators	104
	6.2.1 Background	104
	6.2.2 Multi-level Modelling	105
	6.2.3 People's Use of Simulators	106
6.3	Application 1 – Hospital Consolidation	108
	6.3.1 Model Overview	110
	6.3.2 Results and Conclusions	117
6.4	Application 2 – Enterprise Diagnostics	118
	6.4.1 Automobile Industry Application	119
	6.4.2 Interactive Visualization	122
	6.4.3 Experimental Evaluation	125
	6.4.4 Results and Discussion	125
	6.4.5 Implications	128
6.5	Conclusions	128
	References	129
7	Developing Agent-Based Simulation Models for Social Systems Engineering Studies: A Novel Framework and its Application to Modelling Peacebuilding Activities	133
	<i>Peer-Olaf Siebers, Graziela P. Figueredo, Miwa Hirono and Anya Skatova</i>	
7.1	Introduction	133
7.2	Background	134
	7.2.1 Simulation	134
	7.2.2 Peacebuilding	135
7.3	Framework	137
	7.3.1 Toolkit Design	138
	7.3.2 Application Design	142
7.4	Illustrative Example of Applying the Framework	143
	7.4.1 Peacebuilding Toolkit Design	143
	7.4.2 Peacebuilding Application Design	149
	7.4.3 Engineering Actions and Interventions in a Peacebuilding Context	153
7.5	Conclusions	155
	References	155
8	Using Actor-Network Theory in Agent-Based Modelling	157
	<i>Sandra Méndez-Fajardo, Rafael A. Gonzalez and Ricardo A. Barros-Castro</i>	
8.1	Introduction	157
8.2	Agent-Based Modelling	158

8.2.1	<i>ABM Approaches</i>	159
8.2.2	<i>Agent Interactions</i>	160
8.3	Actor–Network Theory	160
8.4	Towards an ANT-Based Approach to ABM	162
8.4.1	<i>ANT Concepts Related to ABM</i>	162
8.5	Design Guidelines	163
8.6	The Case of WEEE Management	166
8.6.1	<i>Contextualizing the Case Study</i>	167
8.6.2	<i>ANT Applied to WEEE Management in Colombia</i>	168
8.6.3	<i>ANT–ABM Translation Based on the Case Study</i>	172
8.6.4	<i>Open Issues and Reflections</i>	173
8.7	Conclusions	174
	References	175
9	Engineering the Process of Institutional Innovation in Contested Territory	179
	<i>Russell C. Thomas and John S. Gero</i>	
9.1	Introduction	179
9.2	Can Cyber Security and Risk be Quantified?	181
9.2.1	<i>Schools of Thought</i>	181
9.3	Social Processes of Innovation in Pre-paradigmatic Fields	183
9.3.1	<i>Epistemic and Ontological Rivalry</i>	183
9.3.2	<i>Knowledge Artefacts</i>	184
9.3.3	<i>Implications of Theory</i>	184
9.4	A Computational Model of Innovation	186
9.4.1	<i>Base Model: Innovation as Percolation</i>	186
9.4.2	<i>Full Model: Innovation with Knowledge Artefacts</i>	190
9.4.3	<i>Experiment</i>	190
9.5	Discussion	194
	Acknowledgements	194
	References	195
Part III	CASES AND APPLICATIONS	197
10	Agent-Based Explorations of Environmental Consumption in Segregated Networks	199
	<i>Adam Douglas Henry and Heike I. Brugger</i>	
10.1	Introduction	199
10.1.1	<i>Micro-drivers of Technology Adoption</i>	201
10.1.2	<i>The Problem of Network Segregation</i>	202
10.2	Model Overview	203
10.2.1	<i>Synopsis of Model Parameters</i>	204
10.2.2	<i>Agent Selection by Firms</i>	205
10.2.3	<i>Agent Adoption Decisions</i>	206
10.3	Results	206
10.3.1	<i>Influence of Firm Strategy on Saturation Times</i>	207
10.3.2	<i>Characterizing Adoption Dynamics</i>	208
10.3.3	<i>Incentivizing Different Strategies</i>	210

10.4	Conclusion	212
	Acknowledgements	212
	References	213
11	Modelling in the ‘Muddled Middle’: A Case Study of Water Service Delivery in Post-Apartheid South Africa	215
	<i>Jai K. Clifford-Holmes, Jill H. Slinger, Chris de Wet and Carolyn G. Palmer</i>	
11.1	Introduction	215
11.2	The Case Study	216
11.3	Contextualizing Modelling in the ‘Muddled Middle’ in the Water Sector	217
11.4	Methods	219
11.5	Results	220
11.6	Discussion	228
	Acknowledgements	230
	References	231
12	Holistic System Design: The Oncology Carinthia Study	235
	<i>Markus Schwaninger and Johann Klocker</i>	
12.1	The Challenge: Holistic System Design	235
12.2	Methodology	236
12.3	Introduction to the Case Study: Oncology Carinthia	238
	12.3.1 <i>Setting the Stage</i>	238
	12.3.2 <i>Framing: Purpose and Overall Goals (F)</i>	239
	12.3.3 <i>Mapping the System at the Outset (M)</i>	240
	12.3.4 <i>A First Model (M) and Assessment (A)</i>	242
	12.3.5 <i>The Challenge Ahead</i>	245
	12.3.6 <i>A First Take on Design (D): Ascertaining Levers</i>	246
	12.3.7 <i>From Design (D) to Change (C)</i>	248
	12.3.8 <i>Progress in Organizational Design (D)</i>	249
	12.3.9 <i>The Evolution of Oncology Carinthia (C)</i>	258
	12.3.10 <i>Results</i>	259
12.4	Insights, Teachings and Implications	261
	Acknowledgements	263
	Appendix: Mathematical Representations for Figures 12.5, 12.6 and 12.7	263
	A1: VSM, for any System-in-Focus (one level of recursion; ref. Figure 12.5)	263
	A2: Recursive Structure of the VSM (ref. Figure 12.6)	264
	A3: Virtual Teams (ref. Figure 12.7)	264
	References	265
13	Reinforcing the Social in Social Systems Engineering – Lessons Learnt from Smart City Projects in the United Kingdom	267
	<i>Jenny O’Connor, Zeynep Gurguc and Koen H. van Dam</i>	
13.1	Introduction	267
	13.1.1 <i>Cities as Testbeds</i>	268
	13.1.2 <i>Smart Cities as Artificial Systems</i>	268
	13.1.3 <i>Chapter Structure</i>	269
13.2	Methodology	270

13.3	Case Studies	271
	13.3.1 Glasgow	271
	13.3.2 London	274
	13.3.3 Bristol	277
	13.3.4 Peterborough	279
13.4	Discussion	283
	13.4.1 Push/Pull Adoption Model	283
	13.4.2 Civic Engagement	284
	13.4.3 Solutions and Problems	285
	13.4.4 Metrics, Quantification and Optimization	285
	13.4.5 Project Scope and Lifecycles	286
	13.4.6 Collaboration and Multidisciplinarity	286
	13.4.7 Knowledge-Sharing	287
13.5	Conclusion	287
	References	288
Index		291