

Table of Contents

Author Biographies	xi
Introduction	xv
PART 1: ENGINEERING LARGE-SCALE COMPLEX SYSTEMS AND EMERGENCY SITUATION MANAGEMENT	1
Chapter 1. Engineering Large-scale Complex Systems	3
Dominique LUZEAUX	
1.1. Introduction	3
1.2. The notion of service in large complex systems	7
1.3. Architecture: a key concept	11
1.4. Towards resilient systems	13
1.4.1. Resilience: definitions	14
1.4.2. Resilience versus dependability	17
1.4.3. Engineering resilience	18
1.5. Development of relationships between participants	28
1.6. Complexity: plurality of viewpoints for systems engineering	35
1.7. The maintenance and logistics of systems of systems	59
1.8. Perspectives and lines of enquiry	61
1.8.1. Contextual elements	61
1.8.2. Factors of influence	64
1.8.3. Trends, issues and challenges in systems engineering	66
1.8.4. Development of the engineering process	71
1.8.5. Themes of research	76
1.9. Conclusion	79
1.10. Bibliography	82

Chapter 2. Management of Emergency Situations: Architecture and Engineering of Systems of Systems	85
Jean-René RUAULT	
2.1. Introduction	85
2.2. Main concepts of systems engineering	86
2.3. Context of the emergency situation management scenario	89
2.3.1. Global context: Tairétalet	89
2.3.2. Synthesis of the Dubbus accident report	90
2.3.3. Decision of the Tairétalet authorities	92
2.3.4. Analysis of context and participants involved	96
2.3.5. Results of studies on existing resources	99
2.3.6. Emergency situation management scenario: perimeter and architecture	102
2.3.7. Reference operational scenario	102
2.3.8. Alternative operational scenarios	108
2.3.9. Perimeter and component systems of the system of systems	109
2.3.10. System dimensions: lines of development	111
2.4. Architecture of component systems of the system of systems	116
2.4.1. Detecting an accident: the accident detection system	116
2.4.2. Evaluating the gravity of an accident, coordinating the emergency services and allocating casualties to hospitals: the regional call center	135
2.4.3. Casualty evacuation: emergency service centers and hospitals	175
2.4.4. Continuous improvement of emergency situation management	176
2.4.5. Systems engineering for the regional call center, emergency service centers and hospitals	176
2.4.6. Specificities of system of systems engineering	195
2.5. Conclusion	197
2.6. Acknowledgements	197
2.7. Bibliography	198
PART 2: CASE STUDY: ANTARCTICA LIFE SUPPORT FACILITY	205
Chapter 3. Introduction to the Antarctica Life Support Facility Case Study	207
Jean-Luc WIPPLER	
3.1. Why Antarctica?	208
3.2. Fictional context of the study	209
3.2.1. The Antarctica mission	209
3.2.2. The cast of characters	211

3.3. Some data on the Antarctic and Adélie Land	212
3.3.1. Geography	212
3.3.2. Climate	212
3.3.3. Biological patrimony	213
3.3.4. Location of the life support facility	213
3.4. Bibliography	213
Chapter 4. Finding the Right Problem	215
Philippe THUILLIER and Jean-Luc WIPPLER	
4.1. What system are we dealing with?	216
4.1.1. Purpose and missions	217
4.1.2. The system perimeter	219
4.2. System lifecycle	221
4.3. Who does the system involve?	226
4.4. Creating a working framework	228
4.5. Gathering information	229
4.6. Modeling the context	235
4.7. Understanding and defining goals	236
4.8. Modeling the domain	241
4.9. Defining stakeholder requirements and constraints	247
4.10. Things to remember: stakeholder-requirements engineering	251
4.11. Bibliography	252
Chapter 5. Who Can Solve the Problem?	255
Olivier KLOTZ and Jean-Luc WIPPLER	
5.1. Consultation and selection	256
5.1.1. Establishment of an acquisition plan	256
5.1.2. Creating an initial list of companies	258
5.1.3. Organizing and launching a request for information	259
5.1.4. Selecting companies for the call to tender	260
5.1.5. Preparing and launching the call to tender	261
5.1.6. Selecting a partner company	261
5.2. Responding (and winning)	262
5.2.1. Approaching the problem	262
5.2.2. Advancing into the unknown	263
5.2.3. Where should we start?	265
5.2.4. Doing it all simultaneously	269
5.3. Committing to a “right” definition of the system to be created	272
5.3.1. From stakeholder requirements to technical requirements	273
5.3.2. Covering the whole of the System’s lifecycle	274
5.3.3. Accounting for stakeholder expectations and constraints	276
5.3.4. Remaining realistic	277

viii Complex Systems and Systems of Systems Engineering

5.3.5. Removing major risks	278
5.3.6. Facing identified threats	279
5.3.7. Use of precise terminology	282
5.4. Creating the list of technical requirements	284
5.4.1. Creating the necessary model	284
5.4.2. Expressing the “right” technical requirements	286
5.4.3. Compliance with the specification	288
5.5. Things to remember: technical requirements engineering	290
5.6. Bibliography	291
Chapter 6. Solving the Problem	293
Charlotte SEIDNER and Jean-Luc WIPPLER	
6.1. General approach	294
6.2. Functional design	297
6.2.1. A brief introduction to functional design	297
6.2.2. Application	300
6.3. Physical design	313
6.3.1. Identifying physical components	313
6.3.2. Allocation of functions to identified components	315
6.3.3. Grouping components by sub-system	318
6.3.4. Architecture of (some) sub-systems	321
6.3.5. Sub-systems architecture of the life support facility	324
6.4. Interfaces	326
6.4.1. Waste management	330
6.4.2. Centralized supervision	331
6.4.3. Other types of interactions between components	332
6.5. The “playing fields” of the systems architect	333
6.6. EFFBDs	336
6.6.1. An informal introduction to EFFBD diagrams	336
6.6.2. Syntax and structure of EFFBDs	338
6.6.3. Formalization of EFFBDs	338
6.6.4. Verification and validation of EFFBDs	340
6.7. Things to remember: architectural design	342
6.8. Bibliography	343
Chapter 7. Solving the Problem Completely, in a Coherent and Optimal Manner	345
Jean-François GAJEWSKI, Hélène GASPARD-BOULINC and Jean-Luc WIPPLER	
7.1. Making the right technical decisions at the right level and the right time	347
7.1.1. Formalizing possibilities	348

7.1.2. Using a multi-criteria analytical approach	350
7.1.3. Reinforcing and optimizing choices	360
7.1.4. Things to remember	363
7.2. Integrating disciplines.	366
7.2.1. Integrating dependability	368
7.2.2. Integrating the human factor	380
7.2.3. Things to remember	389
7.3. Bibliography	391
Chapter 8. Anticipating Integration, Verification and Validation	393
Daniel PRUN and Jean-Luc WIPPLER	
8.1. Positioning integration, verification and validation	395
8.2. Integration, verification and validation in the system's lifecycle	403
8.3. Analyzing input	405
8.4. Establishing an integration, verification and validation strategy.	407
8.4.1. Identifying integration, verification and validation objectives	408
8.4.2. Stages of integration, verification and validation	415
8.5. Defining the infrastructure	419
8.5.1. Platforms	419
8.5.2. Tools	420
8.5.3. Data	422
8.6. Integration, verification and validation organization.	422
8.7. Choosing techniques	423
8.7.1. Review	424
8.7.2. Testing	425
8.7.3. Traceability	426
8.8. Things to remember: integration, verification and validation	427
8.8.1. Activities linked to engineering	427
8.8.2. Anticipation	427
8.8.3. A multi-faceted approach	428
8.8.4. Strategy: a key point	428
8.8.5. The IVV manager: a high-pressure role	429
8.9. Bibliography	429
Chapter 9. Conclusion to the “Antarctica Life Support Facility” Case Study	431
Jean-Luc WIPPLER	
9.1. “Before we can manage a solution, we need to find one!”	432
9.2. “Modeling isn’t drawing!”	434
9.3. Implementing systems engineering.	437
9.4. Acknowledgements	439
9.5. Bibliography	440

x	Complex Systems and Systems of Systems Engineering
Conclusion	441
List of Authors	443
Index	445