

Contents

1	Introduction	1
1.1	The Industrial Context	1
1.2	Goals of This Handbook	2
1.3	Test Cases and Implementation of Tools	3
1.4	Structure of the Handbook	5
2	The Systems Engineering	7
2.1	A Definition in a Nutshell	7
2.1.1	Main Goals	8
2.1.2	Four Pillars	11
2.2	Some Historical Notes	13
2.3	A Survey on the Literature About the Systems Engineering	15
2.4	Technical Standards on the Systems Engineering	19
2.5	Software Tools for the Systems Engineering	21
	References	22
3	The Methodology of Systems Engineering	25
3.1	Introduction	25
3.1.1	Definitions of System	25
3.1.2	The System Development as an Industrial Product	26
3.2	The Models of the Product Life Cycle	29
3.2.1	The Waterfall Diagram	30
3.2.2	The V-Diagram	30
3.2.3	The Spiral Diagram	33
3.3	The Architecture Frameworks	34
3.3.1	MODAF	35
3.3.2	UAF	37
3.3.3	Framework and Process	39

- 3.4 The Industrial Implementation of the Methodology 39
 - 3.4.1 Key Issues of the SE Process 42
- 3.5 Overview on Known Methodologies to Implement the MBSE. . . 46
 - 3.5.1 The INCOSE Object-Oriented Systems Engineering Methodology (OOSEM) 46
 - 3.5.2 The IBM Rational Telelogic Harmony-SE 47
 - 3.5.3 The IBM Rational Unified Process for System Engineering (RUP-SE) 47
 - 3.5.4 The Vitech Model-Based System Engineering (MBSE). 48
 - 3.5.5 The JPL State Analysis (SA). 48
 - 3.5.6 The Object-Process Methodology (OPM). 48
 - 3.5.7 The Architecture Analysis and Design Integrated Approach (ARCADIA). 49
 - 3.5.8 The Systems Modeling Process (SYSMOD). 49
 - 3.5.9 The Alstom ASAP Methodology 49
 - 3.5.10 Synthesis About the Methodologies 49
- 3.6 A Reference Process: The ISO/IEC 15288 50
- 3.7 The Engineering Methods 52
- 3.8 The Languages for Systems Engineering 56
- 3.9 Unified Modeling Language—UML 57
- 3.10 System Modeling Language—SysML 58
 - 3.10.1 Requirements Diagram 59
 - 3.10.2 Behavior Diagram 60
 - 3.10.3 Structure Diagrams 64
 - 3.10.4 Parametric Diagram 66
- References 67
- 4 Systems, Customer Needs and Requirements 69**
 - 4.1 A Couple of Examples to Understand 69
 - 4.1.1 Didactic Test Case: A Coiler for Wire Rod Production 70
 - 4.1.2 Industrial Test Case: De-icing or Anti-icing System for a Commercial Aircraft 72
 - 4.2 Implementation of the MBSE 73
 - 4.3 Identification of the Customer Needs 74
 - 4.3.1 Needs Versus Requirements 74
 - 4.3.2 Looking for the Customer Needs 74
 - 4.3.3 A Systematic Approach to the Identification of Needs 75
 - 4.3.4 Source of Needs 77

- 4.4 The Stakeholders 78
 - 4.4.1 Didactic Test Case: Needs and Stakeholders 79
 - 4.4.2 Industrial Test Case: Needs and Stakeholders 80
- 4.5 The Role of Requirements in the Product Development 81
 - 4.5.1 Definition of Requirement 82
 - 4.5.2 Classification of Requirements 83
 - 4.5.3 Syntax and Attributes of Requirements 85
- 4.6 Tools for Writing Requirements 86
 - 4.6.1 Requirements Manager 86
 - 4.6.2 Requirements Quality and Authoring Suites 90
- 4.7 Requirements Refinement and Assessment 91
 - 4.7.1 Didactic Test Case: Classification and List of Requirements 91
 - 4.7.2 Industrial Test Case: Classification and List of Requirements 104
- References 113
- 5 Operational Analysis 115**
 - 5.1 Goals and Tasks 115
 - 5.2 The Operational Analysis Deployed Through the SysML 116
 - 5.3 Implementation and Operational Context 119
 - 5.3.1 Didactic Test Case 119
 - 5.3.2 Industrial Test Case 126
 - 5.4 Requirements Derivation in Operational Analysis 139
 - 5.5 Synthesis of the Operational Analysis for Both the Test Cases 143
- 6 Functional Analysis 147**
 - 6.1 Introduction 147
 - 6.2 Handoff Between Operational and Functional Analyses 149
 - 6.3 Implementation of Functional Analysis Through the SysML 150
 - 6.4 Requirements Derivation, Traceability and Allocation 155
 - 6.5 Results and Outputs for the Logical Analysis 157
 - 6.6 Implementation: Deriving the Functional Architecture 158
 - 6.6.1 Didactic Test Case 159
 - 6.6.2 Industrial Test Case 166
 - 6.6.3 Comparison Between Use Case and Black-Box Based Approaches 184
 - 6.7 Results and Final Remarks About the Functional Analysis 190
 - References 191
- 7 Logical Analysis 193**
 - 7.1 Meaning of the Logical Analysis 193
 - 7.2 Handoff Between Functional and Logical Analysis 194

7.3	Implementation of the Logical Analysis Through the SysML . . .	195
7.4	Requirements Satisfaction and Architecture Allocation	199
7.5	Towards the Next Phase	200
7.6	Implementation and System Logical Architecture	201
7.6.1	Didactic Test Case	201
7.6.2	Industrial Test Case	204
7.7	Requirements Traceability in the Logical Analysis	219
7.8	Results and Final Considerations About the Logical Analysis . . .	222
8	Physical Analysis	225
8.1	Introduction	225
8.2	Handoff Between Logical and Physical Analyses	226
8.3	Formalisms and Models of the Physical Analysis	227
8.4	Requirements Allocation and Verification	229
8.5	Expected Results and Final Remarks	230
8.6	Implementation of the Physical Analysis of Complex Systems	231
8.6.1	Didactic Test Case	231
8.6.2	Industrial Test Case	244
8.7	Results and Final Considerations About the Physical Analysis . . .	269
	References	270
9	Heterogeneous Simulation	271
9.1	Introduction	271
9.2	Strategies of Model's Integration Within the Heterogeneous Simulation	272
9.3	Example of Interoperability Standard: The Functional Mock- up Interface	277
9.4	Implementation of the Heterogeneous Simulation in the Ice Protection System Case Study	279
9.4.1	Models for the Ice Protection System Scenario	279
9.4.2	Simulation Results and Final Run	283
9.5	Traceability and Future Evolution of the Interoperability Within Large Toolchains	285
	References	287
10	System Verification and Validation (V&V)	289
10.1	Introduction	289
10.2	The Best "V&V" Process	291
10.3	Verification, Validation and Accreditation (V&V, VV&A)	292
10.4	Software and Hardware	293
10.4.1	V&V in Software Engineering	294
10.4.2	V&V in Hardware Engineering	297
10.5	A Methodological Approach to the Industrial Product V&V . . .	299

- 10.5.1 Practical Issues in Product Development and Relation with V&V 299
- 10.5.2 Workflow of V&V 301
- 10.5.3 Design Objectives 303
- 10.5.4 Smartness and Smart-Nect-Ness 304
- 10.5.5 DT&E and OT&E for the Industrial Product 305
- 10.6 The Role of RAMS in V&V 307
 - 10.6.1 Reliability 307
 - 10.6.2 Maintainability 308
 - 10.6.3 Availability 309
 - 10.6.4 FMEA and FTA 309
 - 10.6.5 Dysfunctional Analysis 310
 - 10.6.6 Integration of RAMS and Numerical Simulation 312
- 10.7 V&V Peculiarities of the Proposed Test Cases 313
 - 10.7.1 Didactic Test Case: V&V Issues 313
 - 10.7.2 Industrial Test Case: The RAMS Analysis 320
- References 325
- 11 Systems Engineering and Product Lifecycle Management (PLM) 327**
 - 11.1 The Big Picture 327
 - 11.2 The Configuration Control Management 328
 - 11.3 The Platform Building 330
 - 11.3.1 The PLM Collaboration Model 331
 - 11.3.2 The PLM Functional View 331
 - 11.3.3 The PLM Data Model Analysis and the Tool Chain 332
 - 11.4 The Tools Integration and Interoperation 335
 - 11.5 The Configuration Control Action 337
 - 11.6 Integration Between Analyses Within the Tool Chain 339
 - 11.6.1 Integration Between Design and RAMS 339
 - 11.6.2 Integrated Analysis 340
- 12 Conclusion 343**
- Index 347**



<http://www.springer.com/978-3-319-71836-1>

Systems Engineering and Its Application to Industrial
Product Development

Brusa, E.; Calà, A.; Ferretto, D.

2018, XXII, 353 p. 217 illus., 197 illus. in color.,

Hardcover

ISBN: 978-3-319-71836-1