
Contents

INTRODUCTION	xiii
CHAPTER 1. FROM THE SYSTEM TO THE SOFTWARE	1
1.1. Introduction	1
1.2. Command/control system	2
1.3. System.	6
1.4. Software application	8
1.4.1. What is software?	8
1.4.2. Different types of software	9
1.4.3. The software application in its proper context	10
1.5. Conclusion	11
CHAPTER 2. RAILWAY STANDARDS	13
2.1. Introduction	13
2.2. Generic standards	14
2.2.1. Introduction	14
2.2.2. Safety levels	15
2.3. History between CENELEC and the IEC	16
2.4. CENELEC referential framework.	17
2.4.1. Introduction	17
2.4.2. Description.	18
2.4.3. Implementation	21
2.4.4. Software safety	22
2.4.5. Safety versus availability	22
2.5. EN 50155 standard	23
2.6. CENELEC 50128	26
2.6.1. Introduction	26

2.6.2. SSIL management	26
2.6.3. Comparison of 2001 and 2011 versions	28
2.7. Conclusion	30
CHAPTER 3. RISK AND SAFETY INTEGRITY LEVEL	31
3.1. Introduction	31
3.2. Basic definitions	31
3.3. Safety enforcement	37
3.3.1. What is safety?	37
3.3.2. Safety management.	40
3.3.3. Safety integrity	47
3.3.4. Determination of the SIL	50
3.3.5. SIL table	55
3.3.6. Allocation of SILs	56
3.3.7. SIL management	57
3.3.8. Software SIL.	58
3.3.9. Iterative process.	59
3.3.10. Identification of safety requirements.	60
3.4. In IEC 61508 and IEC 61511	61
3.4.1. Risk graph	62
3.4.2. LOPA.	64
3.4.3. Overview.	66
3.5. Conclusion	66
CHAPTER 4. SOFTWARE ASSURANCE	67
4.1. Introduction	67
4.2. Prerequisites	67
4.3. Quality assurance	68
4.3.1. Introduction	68
4.3.2. Quality assurance management.	69
4.3.3. Realization of a software application	73
4.3.4. Software quality assurance plan (SQAP)	75
4.4. Organization	78
4.4.1. Typical organization	78
4.4.2. Skill management.	80
4.5. Configuration management	82
4.6. Safety assurance management.	84
4.7. Verification and validation.	86
4.7.1. Introduction	86
4.7.2. Verification	87
4.7.3. Validation	103

4.8. Independent assessment	104
4.9. Tool qualification	104
4.10. Conclusion	105
4.11. Appendix A: list of quality documents to be produced	106
4.12. Appendix B: structure of a software quality assurance plan.	106
CHAPTER 5. REQUIREMENTS MANAGEMENT	109
5.1. Introduction	109
5.2. Requirements acquisition phase.	110
5.2.1. Introduction	110
5.2.2. Requirements elicitation.	111
5.2.3. Process of analysis and documentation	119
5.2.4. Verification and validation of the requirements	126
5.3. Requirements specification	129
5.3.1. Requirements characterization	129
5.3.2. Characterization of requirements specification.	135
5.3.3. Expression of requirements	135
5.3.4. Requirements validation.	140
5.4. Requirements realization	140
5.4.1. Process	140
5.4.2. Verification	141
5.4.3. Traceability	143
5.4.4. Change management.	146
5.5. Requirements management	150
5.5.1. Activities.	150
5.5.2. Two approaches.	151
5.5.3. Implementation of tools	152
5.6. Conclusion	154
CHAPTER 6. DATA PREPARATION	155
6.1. Introduction	155
6.2. Recap	156
6.3. Issue	156
6.4. Data-parameter-based system	158
6.4.1. Introduction	158
6.4.2. Characterization of data	161

6.4.3. Service inhibition	162
6.4.4. Overview	164
6.5. From the system to the software	165
6.5.1. Need	165
6.5.2. What the CENELEC framework does not say	167
6.6. Data preparation process	169
6.6.1. Context	169
6.6.2. Presentation of section 8 of the CENELEC 50128:2011 standard	170
6.7. Data preparation process	174
6.7.1. Management of the data preparation process	174
6.7.2. Verification	182
6.7.3. Specification phase	182
6.7.4. Architecture phase	186
6.7.5. Data production	190
6.7.6. Integration of the application and acceptance of the tests	196
6.7.7. Validation and evaluation of the application	197
6.7.8. Procedure and tools for preparation of the application	197
6.7.9. Development of generic software	198
6.8. Conclusion	199
6.9. Appendix: documentation to be produced	199
CHAPTER 7. GENERIC APPLICATION	201
7.1. Introduction	201
7.2. Software application realization process	201
7.3. Realization of a generic application	203
7.3.1. Specification phase	203
7.3.2. Architecture and component design phase	213
7.3.3. Component design phase	236
7.3.4. Coding phase	242
7.3.5. Execution of component tests	243
7.3.6. Software integration phase	246
7.3.7. Overall software testing phase	247
7.4. Some feedback on past experience	249
7.5. Conclusion	250
7.6. Appendix A: the programming language “Ada”	251
7.7. Appendix B: the programming language “C”	253
7.7.1. Introduction	253

7.7.2. The difficulty with C	253
7.7.3. MISRA-C	254
7.7.4. Example of a rule	255
7.8. Appendix C: introduction to object-oriented languages	255
7.9. Appendix D: documentation needing to be produced	258
CHAPTER 8. MODELING AND FORMALIZATION	261
8.1. Introduction	261
8.2. Modeling	261
8.2.1. Objectives	261
8.2.2. Different types of modeling	263
8.2.3. Model	264
8.3. Use of formal techniques and formal methods	265
8.3.1. Definitions	265
8.3.2. UML	268
8.4. Brief introduction to formal methods	269
8.4.1. Recap	269
8.4.2. Usage in the railway domain	270
8.4.3. Summary	276
8.5. Implementation of formal methods	279
8.5.1. Conventional processes	279
8.5.2. Process including formal methods	280
8.5.3. Issues	282
8.6. Maintenance of the software application	284
8.7. Conclusion	285
CHAPTER 9. TOOL QUALIFICATION	287
9.1. Introduction	287
9.2. Concept of qualification	288
9.2.1. Issue	288
9.2.2. CENELEC 50128:2001	288
9.2.3. DO-178	291
9.2.4. IEC 61508	292
9.2.5. ISO 26262	293
9.3. CENELEC 50128:2011	293
9.3.1. Introduction	293
9.3.2. Qualification file	294

9.3.3. Qualification process	295
9.3.4. Implementation of the qualification process	297
9.4. Fitness for purpose	305
9.4.1. Design method	305
9.4.2. In case of incompatibility	305
9.4.3. Code generation.	306
9.5. Version management	306
9.5.1. Identification of versions	306
9.5.2. Bug/defect analysis.	307
9.5.3. Changing versions	307
9.6. Qualification process	307
9.6.1. Qualification file	307
9.6.2. Ultimately	308
9.6.3. Qualification of non-commercial tools	308
9.7. Conclusion	308
CHAPTER 10. MAINTENANCE AND DEPLOYMENT	309
10.1. Introduction	309
10.2. Requirements	309
10.2.1. Fault management.	309
10.2.2. Managing changes	310
10.3. Deployment	312
10.3.1. Issue	312
10.3.2. Implementation	313
10.3.3. In reality	314
10.4. Software maintenance.	315
10.4.1. Issue	315
10.4.2. Implementation	315
10.5. Product line	316
10.6. Conclusion	318
10.7. Appendix: documentation needling to be produced.	319
CHAPTER 11. ASSESSMENT AND CERTIFICATION	321
11.1. Introduction	321
11.2. Evaluation	321
11.2.1. Principles	321
11.2.2. CENELEC 50128:2011	324
11.3. Cross-acceptance.	325
11.4. Certification.	326
11.4.1. Product certification	326

11.4.2. Software certification.	327
11.4.3. Evolution management.	327
11.5. Conclusion	328
11.6. Appendix: documentation needing to be produced.	328
CONCLUSION	329
BIBLIOGRAPHY	331
GLOSSARY	343
INDEX	351