

Contents

1 Foreword	1
References	4
2 Forty Years of Product Data Management from PDM via PLM to SysLM	5
2.1 Document Management System (DMS)	6
2.2 Product Data Management (PDM)	7
2.3 Product Lifecycle Management (PLM)	10
2.4 On the Path to System Lifecycle Management	18
References	24
3 Engineering 4.0—Foundations of the Digitalization of Engineering	27
3.1 Digitalization—Buzzword or Challenge?	28
3.2 Digitization, Digitalization, and Digital Transformation	38
3.3 Internet of Things (IOT), Systems of Systems (SOS), Industry 4.0, Industrial Internet, and Internet of Services (IOS)	40
3.4 Digital Twin and Digital Thread	46
3.4.1 Digital Twin	47
3.4.2 Digital Thread	57
3.4.3 Implementation of Digital Twin and Digital Thread in Operational Practice	59
3.5 Model-Based Systems Engineering, System Thinking, and the System Model	61
3.5.1 Discipline-Oriented Approach in Product Development	61
3.5.2 Systems Engineering	64
3.5.3 Systems Thinking	65
3.5.4 Model-Based Engineering and Model-Based Systems Engineering	67
3.5.5 The Digital Model	68
3.5.6 The System Model	70

3.6	A New Interdisciplinary Design Methodology	73
3.6.1	VPESystemDevelopment _{Methodology}	75
3.6.2	Detailed Implementation of the System Model at a Micro-methodology Level	83
3.6.3	Validation of the VPESystemDevelopment _{Methodology}	91
	References	94
4	Engineering 4.0—Implementation of the Digitalization of Engineering	101
4.1	The Digitalization of Products and Services	102
4.2	The Digitalization of the Engineering Processes	107
4.2.1	Vertical Integration and Digitalization	109
4.2.1.1	Requirements Management and Requirements Development (→ Requirements Engineering)	111
4.2.1.2	System Architecture Model (SAM) and System Model (SM)	114
4.2.1.3	CAX Integration	120
4.2.1.4	Simulation Integration into SysLM	152
4.2.2	Horizontal Integration and Digitalization	160
4.2.2.1	Standardized Company-Wide Technical Organization	160
4.2.2.2	Integration of the Product Lifecycle Phases	182
4.3	Technical Requirements on SysLM	219
4.4	Validation of the Maturity of Digitalization in Engineering	226
4.4.1	Maturity Models	227
	References	232
5	Bimodal SysLM Systems and Agile Implementation	239
5.1	Vision SysLM Versus Actual Status of Current PLM Implementations ...	240
5.2	Innovative Products/Systems and Business Models Present New Challenges for SysLM	241
5.3	Reduction in the Total Cost of Ownership with Bimodal SysLM	243
5.4	The Agile Implementation of SysLM systems	248
5.4.1	Integration of Product Engineering and Supply Chains to support OnePDM	250
5.4.2	Best Practice	255
5.4.3	Benefits	257
	References	257
6	Summary	259
	Reference	262
	Appendix	263