

Decision Engineering

John Stark

# Product Lifecycle Management (Volume 1)

21st Century Paradigm for Product  
Realisation

*Fifth Edition*



 Springer

---

# Decision Engineering

## Series Editor

Rajkumar Roy, Dean of the School of Mathematics, Computer Science and Engineering, City University, London, UK

The Decision Engineering series focuses on the foundations and applications of tools and techniques related to decision engineering, and identifies their role in making decisions. The series provides an aid to practising professionals and applied researchers in the development of tools for informed operational and business decision making, within industry, by utilising distributed organisational knowledge. Series topics include:

- Cost Engineering and Estimating,
- Soft Computing Techniques,
- Classical Optimization and Simulation Techniques,
- Micro Knowledge Management (including knowledge capture and reuse, knowledge engineering and business intelligence),
- Collaborative Technology and Concurrent Engineering, and
- Risk Analysis.

Springer welcomes new book ideas from potential authors. If you are interested in writing for the Decision Engineering series please contact: Anthony Doyle (Senior Editor—Engineering, Springer) and Professor Rajkumar Roy (Series Editor) at: [anthony.doyle@springer.com](mailto:anthony.doyle@springer.com) or [r.roy@city.ac.uk](mailto:r.roy@city.ac.uk)

More information about this series at <https://link.springer.com/bookseries/5112>

---

John Stark

# Product Lifecycle Management (Volume 1)

21st Century Paradigm for Product  
Realisation

Fifth Edition

John Stark  
John Stark Associates  
Geneva, Switzerland

ISSN 1619-5736

ISSN 2197-6589 (electronic)

Decision Engineering

ISBN 978-3-030-98577-6

ISBN 978-3-030-98578-3 (eBook)

<https://doi.org/10.1007/978-3-030-98578-3>

1<sup>st</sup>–4<sup>th</sup> edition: © Springer Nature Switzerland AG 2005, 2011, 2015, 2020

5<sup>th</sup> edition: © The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

---

## Preface

This is the fifth edition of what has become the PLM Reference Book. Product Lifecycle Management (PLM) is the business activity of managing, in the most effective way, a company's products all the way across their lifecycles, from the very first idea for a product all the way through until it is retired and disposed of.

PLM is about “managing products across their lifecycles”, and it applies to any company with a product. It applies in all sizes of companies, ranging from large multinational corporations to small and medium enterprises. It's applied across a wide range of industrial sectors including aerospace, apparel, automotive, beverage, consumer goods, construction equipment, defence, electrical engineering, electronics, food, life sciences, machinery, machine tool, mechanical engineering, medical equipment, pharmaceutical, plastics, shipbuilding, shoe, software, transportation, and turbine.

In the middle of the twentieth century, between 1945 and 1970, things changed little in the world of products. Companies, and their executives, managers and employees worked out how to succeed in that environment. They had an accepted way of thinking, a paradigm, about the way products were managed. For example, companies were organised by department, there was a multilevel hierarchy of middle managers, information was on paper, secretaries produced technical reports on typewriters, and engineers used slide rules for calculations. The Iron Curtain divided the capitalist West from the communist East. In the USA and Western Europe, engineers were predominantly men, white and white-shirted.

The 1970s saw the beginning of a period of a change. It's worth remembering that Intel was founded in 1968, Microsoft in 1975 and Apple in 1976.

In the fifty years between 1970 and 2020, the product landscape changed rapidly and significantly. Many new products appeared as a result of the Electronics Revolution, the Software Revolution, the Biotechnology Revolution and the Nanotechnology Revolution. The Internet and the World Wide Web emerged. Many new products were mechatronic, containing mechanical, electrical, electronic and software components. The development time and the lifetime of many products was slashed. As well as changes in products, there were changes in the environment in which products were sold and used. There were geopolitical changes such as globalisation, the end of the Cold War and the emergence of China as a major manufacturing country. Other changes resulted from concerns about global

warming, the environment and sustainability. In response to all these changes, the paradigm for managing products changed. The new paradigm, PLM, emerged at the beginning of the twenty-first century.

What is this new paradigm? In other words, how should a company, its executives, managers and employees be organised and work in this new environment? And another question, how should a company transition from the old paradigm to the new paradigm? What set of actions will a company have to execute to achieve the change? This book answers these questions.

The PLM paradigm emerged at the beginning of the twenty-first century and has been evolving since then. It was described in the first edition of this book, which was published in 2004. The second edition of the book was published in 2011, the third in 2015 and the fourth in 2019. Since then, the paradigm has continued to evolve. There have been more changes in technologies, products and the PLM environment. PLM has become more and more important. And, due to technological advances, new opportunities for PLM have appeared. This fifth edition of the book addresses these advances and the ever-increasing application of PLM. As for the previous editions, it draws on the extensive PLM consulting activities and experience of the author.

The underlying logic for the structure and content of the book is built on the PLM Grid, a concept outlined in the first chapter. The PLM Grid shows the ten components: product; business processes; product data; the Product Data Management system; other PLM applications; facilities and equipment; techniques; people; management and organisation; and objectives and metrics that have to be addressed when managing a product across the lifecycle.

The book has eighteen chapters. Chapters 1 and 2 introduce PLM and the PLM environment. Chapter 3 addresses products. Chapter 4 focuses on business processes. The subject of Chap. 5 is product data. Chapter 6 addresses Product Data Management systems. Chapter 7 looks at other PLM applications. The content of Chap. 8 includes techniques and methods in the PLM environment. The subject of Chap. 9 is the Internet of Things. That of Chap. 10 is Industry 4.0 and the manufacturing environment. Chapters 11 and 12 address Digital Twins and Digital Threads. Chapters 13 and 14 look at Organisational Change Management (OCM) and project management. The subject of Chap. 15 is the role of executives in PLM, and that of Chap. 16 is the PLM Initiative. Chapter 17 gives examples of PLM in industry.

Many of the chapters address subjects, for example, OCM, that are huge areas in themselves. There are already many books addressing these subjects. The intention of these chapters isn't to repeat everything known about the subject. Instead, it's to provide, for the specific environment of PLM, an introduction that will enable people to work more effectively on PLM activities. The book can be thought of as "PLM 101". It will be useful for those working on a company's PLM activities. It will be a good on-boarding tool for anyone joining a PLM Initiative. It will also be useful for undergraduate and postgraduate university students learning about PLM.

The author has worked with more than 100 companies of many sizes, and in many industries, during the emergence and growth of PLM. Sharing the resulting

---

experience and knowledge meets the innate human desire to improve the world. PLM is, of course, important for companies. By adopting and improving PLM, companies increase product revenues, reduce product-related costs, maximise the value of the product portfolio and maximise the value of current and future products for both customers and shareholders. But, in a wider sense, PLM is also important for mankind. The planet's 7 billion inhabitants all rely on products of various types, and the great majority would benefit from faster, easier access to better products. PLM is a win-win for us all.

Geneva, Switzerland

John Stark



---

# Contents

<b>1</b>	<b>Product Lifecycle Management (PLM)</b> . . . . .	<b>1</b>
1.1	What Is PLM? . . . . .	1
1.1.1	Definition of PLM . . . . .	1
1.1.2	Definition of the PLM Initiative . . . . .	1
1.1.3	A Paradigm . . . . .	2
1.2	This Chapter . . . . .	3
1.2.1	Objective . . . . .	3
1.2.2	Content . . . . .	3
1.2.3	Relevance . . . . .	4
1.3	The P, L and M of PLM . . . . .	4
1.3.1	The P of PLM . . . . .	4
1.3.2	The L of PLM . . . . .	5
1.3.3	The M of PLM . . . . .	6
1.4	The Scope of PLM . . . . .	7
1.4.1	Activities in the Scope of PLM . . . . .	7
1.4.2	The PLM Grid . . . . .	8
1.4.3	Resources in the Scope of PLM . . . . .	8
1.5	The PLM Paradigm . . . . .	12
1.5.1	Paradigm Change . . . . .	13
1.5.2	From Twentieth Century Paradigm to PLM . . . . .	14
1.5.3	Organisation of Work . . . . .	14
1.5.4	Orientation: From Technical to Business . . . . .	16
1.5.5	Information Calculation, Storage and Communication . . . . .	17
1.5.6	Span of Interest . . . . .	18
1.5.7	Value of Product Data . . . . .	19
1.5.8	Management Approach . . . . .	19
1.5.9	Focus . . . . .	20
1.6	PLM Consequences . . . . .	21
1.7	PLM Corollaries . . . . .	23
1.8	The Spread of PLM . . . . .	24

1.9	Benefits of PLM . . . . .	25
1.9.1	Financial, Time, Quality . . . . .	25
1.9.2	Operational Benefits . . . . .	27
1.10	Overcoming Problems, Enabling Opportunities . . . . .	27
1.10.1	Managing the Product Isn't Easy . . . . .	28
1.10.2	Loss of Control . . . . .	28
1.10.3	Sources of Problems . . . . .	30
1.10.4	Opportunities . . . . .	31
	Bibliography . . . . .	32
<b>2</b>	<b>PLM and Its Environment . . . . .</b>	<b>33</b>
2.1	This Chapter . . . . .	33
2.1.1	Objective . . . . .	33
2.1.2	Content . . . . .	33
2.1.3	Relevance . . . . .	34
2.2	Issues with the Departmental Paradigm . . . . .	37
2.2.1	Serial Workflow . . . . .	37
2.2.2	Departmental Organisations . . . . .	39
2.2.3	Piecemeal Improvements . . . . .	41
2.3	Product Data Issues . . . . .	42
2.3.1	A Lot of Product Data . . . . .	42
2.3.2	Poor Change Management . . . . .	43
2.3.3	Data not Linked to Management Tools . . . . .	44
2.4	A Complex, Changing Environment . . . . .	44
2.4.1	Change . . . . .	44
2.4.2	Interconnections . . . . .	45
2.4.3	Changes Driving PLM . . . . .	50
2.4.4	Result . . . . .	51
2.5	Example from "Before PLM" . . . . .	52
2.5.1	Introduction . . . . .	52
2.5.2	Quantitative Feedback . . . . .	55
2.6	Product Pains . . . . .	55
2.6.1	Aerospace Products . . . . .	56
2.6.2	Power Plants . . . . .	58
2.6.3	Automotive Products . . . . .	58
2.6.4	Financial Products . . . . .	59
2.6.5	Other Products . . . . .	60
2.6.6	Current and Future Nightmare . . . . .	61
2.7	Product Opportunities . . . . .	63
2.7.1	Globalisation Opportunity . . . . .	63
2.7.2	Technology Opportunities . . . . .	63
2.7.3	Social/Environmental Opportunity . . . . .	66
2.7.4	Human Resource Opportunity . . . . .	67
2.7.5	The Result and the Requirements . . . . .	67
	Bibliography . . . . .	68

<b>3</b>	<b>PLM and Products</b>	71
3.1	This Chapter	71
3.1.1	Objective	71
3.1.2	Content	71
3.2	Product Importance, Range, Instance	72
3.2.1	Importance of the Product	72
3.2.2	Wide Range of Products	72
3.2.3	More Than the Product	72
3.2.4	Instance of a Product	73
3.2.5	Number of Products	73
3.2.6	Hazardous Products	73
3.2.7	Commonality	74
3.3	Parts, Ingredients, Components, Assemblies	74
3.3.1	Range of Parts	74
3.3.2	Number of Parts	75
3.3.3	Part and Product	75
3.4	Identifier	76
3.4.1	Need for an Identifier	76
3.4.2	Name, Number	76
3.4.3	Internal and Other, Names/Numbers	76
3.4.4	Serial Numbers	77
3.4.5	Significant Numbers	77
3.4.6	Product Key	78
3.4.7	Naming Languages	78
3.4.8	Some Product and Part Identifiers	78
3.4.9	Product Name and Part Name	79
3.5	Requirements	79
3.5.1	Customer Requirements	79
3.5.2	Emergence of Global Products	80
3.5.3	Requirements for Global Products	81
3.6	From Customer Requirement to Product Specification	81
3.7	Identification Standards	82
3.7.1	Global Trade Item Number	82
3.7.2	International Standard Book Number	83
3.7.3	International Mobile Equipment Identity	83
3.7.4	International Standard Music Number	83
3.7.5	CAS Registry Numbers	84
3.8	Unique Identifier, Unique Key	84
3.9	Traceability	84
3.10	Communication of Identifier	84
3.10.1	Type of Communication	85
3.10.2	UPC Barcode	85
3.10.3	EAN-13	85
3.10.4	Two-dimensional Barcodes	85

3.11	Product Classification . . . . .	85
	3.11.1 Classification . . . . .	86
	3.11.2 Advantages of Classification . . . . .	86
	3.11.3 Classification Systems . . . . .	86
3.12	Versions, Variants, Options . . . . .	87
	3.12.1 Lifecycle State . . . . .	87
	3.12.2 Version, Iteration . . . . .	87
	3.12.3 Variant, Option . . . . .	87
	3.12.4 Product Life, Lifetime . . . . .	87
3.13	Product Ownership . . . . .	88
	3.13.1 Rights . . . . .	88
	3.13.2 Intellectual Property . . . . .	88
3.14	Product Structure and Architecture . . . . .	88
	3.14.1 Structures . . . . .	88
	3.14.2 Bill of Materials . . . . .	90
	3.14.3 Product Architecture . . . . .	91
	3.14.4 Product Portfolio . . . . .	92
	3.14.5 Product Model . . . . .	92
3.15	Description, Definition and Representation . . . . .	93
3.16	From Customer Requirement to Performance . . . . .	93
3.17	No Product Is an Island . . . . .	93
3.18	Causes of Product Problems . . . . .	94
	3.18.1 Challenger . . . . .	95
	3.18.2 Columbia . . . . .	95
	3.18.3 SR-111 . . . . .	95
	3.18.4 Ariane 5 . . . . .	96
	3.18.5 Multiple Causes . . . . .	97
3.19	The Challenges . . . . .	97
	Bibliography . . . . .	98
<b>4</b>	<b>PLM and Business Processes . . . . .</b>	<b>99</b>
4.1	This Chapter . . . . .	99
	4.1.1 Objective . . . . .	99
	4.1.2 Content . . . . .	99
	4.1.3 Relevance of Business Processes in PLM . . . . .	100
4.2	Definitions and Introduction . . . . .	102
	4.2.1 Definitions . . . . .	102
	4.2.2 Action Across the Product Lifecycle . . . . .	103
	4.2.3 Organising the Action . . . . .	104
	4.2.4 Process Approach . . . . .	106
	4.2.5 Tools to Represent Business Processes . . . . .	111
	4.2.6 Documenting Processes . . . . .	113
	4.2.7 KPIs for Business Processes . . . . .	120
	4.2.8 The Importance of Business Processes in PLM . . . . .	121

4.3	Process Reality in a Typical Company . . . . .	122
4.3.1	Generic Issues with Business Processes . . . . .	122
4.3.2	Interaction with Other Activities . . . . .	124
4.3.3	Interaction with Company Initiatives . . . . .	125
4.3.4	Generic Challenges with Business Processes . . . . .	125
4.3.5	A Generic Vision for Business Processes in PLM . . . . .	125
4.4	Business Process Activities in the PLM Initiative . . . . .	129
4.4.1	Projects Related to Business Processes . . . . .	130
4.4.2	Business Process Improvement . . . . .	130
4.4.3	Business Process Mapping and Modelling . . . . .	131
4.4.4	The ECM Business Process . . . . .	132
4.4.5	The NPD Business Process . . . . .	138
4.4.6	The Portfolio Management Process . . . . .	141
4.5	Learning from Experience . . . . .	146
4.5.1	From the Trenches . . . . .	146
4.5.2	Business Process Improvement Approach . . . . .	150
4.5.3	Pitfalls of Business Process Mapping and Modelling . . . . .	153
4.5.4	Top Management Role with Business Processes . . . . .	154
	Bibliography . . . . .	155
<b>5</b>	<b>PLM and Product Data . . . . .</b>	<b>159</b>
5.1	This Chapter . . . . .	159
5.1.1	Objective . . . . .	159
5.1.2	Content . . . . .	159
5.1.3	Relevance of Product Data in PLM . . . . .	160
5.2	Definitions and Introduction . . . . .	162
5.2.1	Definitions . . . . .	162
5.2.2	Product Data Across the Lifecycle . . . . .	165
5.2.3	Organising the Product Data . . . . .	166
5.2.4	Product Data as a Strategic Resource . . . . .	168
5.2.5	Tools to Represent Product Data . . . . .	172
5.2.6	Data Model Diagrams . . . . .	173
5.2.7	KPIs for Product Data . . . . .	176
5.2.8	The Importance of Product Data in PLM . . . . .	176
5.3	Reality in a Typical Company . . . . .	177
5.3.1	Generic Issues with Product Data . . . . .	177
5.3.2	Interaction with Other Activities . . . . .	197
5.3.3	Interaction with Company Initiatives . . . . .	198
5.3.4	Generic Challenges and Objectives . . . . .	198
5.3.5	A Generic Vision for Product Data in PLM . . . . .	198
5.4	Product Data Activities in the PLM Initiative . . . . .	200
5.4.1	Product Data-Related Projects . . . . .	200
5.4.2	Product Data Modelling . . . . .	201
5.4.3	Product Data Improvement . . . . .	201

5.4.4	Product Data Cleansing . . . . .	202
5.4.5	Product Data Migration . . . . .	203
5.5	Learning from Experience . . . . .	204
5.5.1	From the Trenches . . . . .	204
5.5.2	Product Data Improvement Approach . . . . .	208
5.5.3	Pitfalls of Product Data Modelling . . . . .	213
5.5.4	Top Management Role with Product Data . . . . .	213
	Bibliography . . . . .	215
<b>6</b>	<b>PLM and PDM . . . . .</b>	<b>217</b>
6.1	This Chapter . . . . .	217
6.1.1	Objective . . . . .	217
6.1.2	Content . . . . .	217
6.1.3	Definition . . . . .	218
6.1.4	Relevance of PDM Systems . . . . .	218
6.2	Many Names and Acronyms . . . . .	218
6.3	PDM System Overview . . . . .	220
6.4	Importance of the PDM System . . . . .	221
6.5	Benefits of PDM Systems . . . . .	223
6.6	The Eight Components . . . . .	223
6.6.1	Information Warehouse . . . . .	223
6.6.2	Information Warehouse Manager . . . . .	225
6.6.3	Infrastructure . . . . .	226
6.6.4	System Administration Manager . . . . .	226
6.6.5	Interface Module . . . . .	227
6.6.6	Product and Workflow Structure Definition Module . . . . .	227
6.6.7	Workflow Control Module . . . . .	229
6.6.8	Information Management Module . . . . .	230
6.7	Common Issues . . . . .	231
6.7.1	Naming, Functionality, Scope . . . . .	231
6.7.2	Change, Version Management . . . . .	232
6.7.3	Interfaces . . . . .	232
6.7.4	Data Model, Workflow . . . . .	232
6.7.5	Ownership, Funding, Support . . . . .	233
6.7.6	Fit in IS Architecture . . . . .	233
6.7.7	Customisation, Installation . . . . .	234
6.7.8	Everyday Use . . . . .	235
6.7.9	Sources of Challenges . . . . .	236
6.8	Guidelines for PDM System Implementation . . . . .	236
6.9	Pitfalls of PDM System Implementation . . . . .	237
6.10	Little Data Management Excitement . . . . .	237
6.11	No PDM System is an Island . . . . .	238
	Bibliography . . . . .	239

---

<b>7</b>	<b>PLM and Product-Related Applications</b>	<b>241</b>
7.1	This Chapter	241
7.1.1	Objective	241
7.1.2	Content	241
7.1.3	Definition	242
7.1.4	Relevance of PLM Applications	242
7.2	Introduction to PLM Applications	242
7.2.1	Additive Manufacturing Applications	242
7.2.2	Application Lifecycle Management	243
7.2.3	Artificial Intelligence	244
7.2.4	Augmented Reality	244
7.2.5	BOM Applications	244
7.2.6	Compliance Management	244
7.2.7	CSM Applications	245
7.2.8	CAD Applications	245
7.2.9	CAE Applications	245
7.2.10	CAID Applications	246
7.2.11	CAM Applications	246
7.2.12	CAPE Applications	246
7.2.13	CAPP Applications	246
7.2.14	CASE Applications	247
7.2.15	CIM	247
7.2.16	Data Exchange Applications	247
7.2.17	DECM Applications	247
7.2.18	Digital Manufacturing Applications	247
7.2.19	DMU Applications	248
7.2.20	EDI Applications	248
7.2.21	EDA Applications	248
7.2.22	ECM Applications	248
7.2.23	EDM Systems	248
7.2.24	Factory Automation	248
7.2.25	FEA Applications	249
7.2.26	Geometric Modelling Applications	249
7.2.27	Haptic Applications	249
7.2.28	IM Applications	249
7.2.29	IoT Platforms	249
7.2.30	IPM Applications	249
7.2.31	Knowledge Based Systems	250
7.2.32	LCA Applications	250
7.2.33	Machine Learning Applications	251
7.2.34	Manufacturing Automation	251
7.2.35	MRP 2 Applications	251
7.2.36	NC Applications	251
7.2.37	Parts Catalogue Applications	251

7.2.38	Parts Libraries	251
7.2.39	Phase-Gate Applications	251
7.2.40	Portfolio Management Applications	252
7.2.41	PDM Systems	252
7.2.42	Project Management Applications	252
7.2.43	RP Applications	252
7.2.44	Requirements Management Applications	253
7.2.45	Reliability Management Applications	253
7.2.46	Simulation Applications	253
7.2.47	SCM Applications	254
7.2.48	Service Management Applications	254
7.2.49	TDM Applications	254
7.2.50	Technical Publication Applications	254
7.2.51	Translation Management Applications	254
7.2.52	VR Applications	255
7.2.53	VE Applications	255
7.2.54	Virtual Prototyping Applications	255
7.2.55	Visualisation and Viewing Applications	255
7.2.56	3D Printing Applications	255
7.2.57	3D Scanning Applications	255
7.3	PLM Applications in the Product Lifecycle	256
7.3.1	Generic and Specific PLM Applications	257
7.3.2	Generic PLM Applications	258
7.3.3	Specific PLM Applications	259
7.3.4	Organising the Applications	261
7.3.5	KPIs for PLM Applications	264
7.4	Reality in a Typical Company	265
7.4.1	Generic Issues with PLM Applications	265
7.4.2	Interaction with Other Activities	268
7.4.3	Interaction with Company Initiatives	268
7.4.4	Generic Challenges with PLM Applications	268
7.4.5	A Generic Vision for PLM Applications	269
7.5	Application Activities in the PLM Initiative	270
7.5.1	Application-Related Projects	270
7.5.2	PLM Application Status Review	271
7.5.3	Software Development Approaches	273
7.5.4	PDM System Selection and Implementation	274
7.6	Best Practice PDM System Selection	276
7.6.1	Prepare the PDM System Project	277
7.6.2	Document the Business Objectives	278
7.6.3	Document the Current Situation	279
7.6.4	Identify PDM System Requirements	284
7.6.5	Know Your Partners	287
7.6.6	Pre-Align with Your Partners	293



7.6.7	Align and Plan with Your Partners . . . . .	293
7.6.8	Carry Out Detailed Design and Planning . . . . .	294
7.6.9	Build and Plan the PDM System . . . . .	294
7.6.10	Test and Validate the PDM System . . . . .	294
7.6.11	Deploy the PDM System . . . . .	295
7.6.12	Use the PDM System . . . . .	295
7.6.13	Support and Sustain the PDM System . . . . .	296
7.6.14	Review PDM System Performance . . . . .	296
7.6.15	Achieve Breakeven for the PDM System . . . . .	296
7.7	Learning from Experience . . . . .	297
7.7.1	From the Trenches . . . . .	297
7.7.2	Pitfalls of Application Implementation . . . . .	299
7.7.3	Top Management Role with PLM Applications . . . . .	299
	Bibliography . . . . .	300
<b>8</b>	<b>PLM, Techniques and Methods . . . . .</b>	<b>303</b>
8.1	This Chapter . . . . .	303
8.1.1	Objective . . . . .	303
8.1.2	Content . . . . .	303
8.2	Introduction . . . . .	304
8.2.1	The Need . . . . .	305
8.2.2	Improvement Initiatives . . . . .	306
8.3	Overview of Methods . . . . .	306
8.3.1	ABC . . . . .	306
8.3.2	Alliance Management . . . . .	307
8.3.3	Benchmarking . . . . .	307
8.3.4	BPR . . . . .	307
8.3.5	CWQC . . . . .	308
8.3.6	Concurrent Engineering . . . . .	308
8.3.7	CM . . . . .	308
8.3.8	Continuous Improvement . . . . .	308
8.3.9	COQM . . . . .	309
8.3.10	Customer Involvement . . . . .	309
8.3.11	DFA . . . . .	310
8.3.12	DFE . . . . .	310
8.3.13	DFM . . . . .	310
8.3.14	DFR . . . . .	310
8.3.15	DFSS . . . . .	311
8.3.16	DFS . . . . .	311
8.3.17	Design Rules . . . . .	311
8.3.18	DTC . . . . .	311
8.3.19	EMI . . . . .	311
8.3.20	ESI . . . . .	312
8.3.21	FMECA . . . . .	312
8.3.22	FTA . . . . .	312

8.3.23	GT	312
8.3.24	Hoshin Kanri	312
8.3.25	JIT	313
8.3.26	Kome Hyappyo	313
8.3.27	Lean Production	313
8.3.28	LCA	314
8.3.29	LCD	314
8.3.30	Open Innovation	315
8.3.31	Phase/Gate Methodology	315
8.3.32	PDCA	316
8.3.33	Platform Strategy	316
8.3.34	Poka-Yoke	316
8.3.35	Process Mapping	316
8.3.36	Project Management	316
8.3.37	QFD	317
8.3.38	Roadmapping	317
8.3.39	Reliability Engineering	317
8.3.40	Robust Engineering	317
8.3.41	Simultaneous Engineering	318
8.3.42	Software Development Methodologies	318
8.3.43	Standards	319
8.3.44	SPC	319
8.3.45	STEP	319
8.3.46	System Engineering	319
8.3.47	Taguchi Techniques	320
8.3.48	Teamwork	320
8.3.49	TCO	320
8.3.50	TQ	320
8.3.51	TQM	320
8.3.52	Triz	321
8.3.53	VA and VE	321
8.4	Some Characteristics of Methods	322
8.4.1	Unclear Name	322
8.4.2	Overlap Between Methods	322
8.4.3	Overlap Between Methods and Applications	322
8.4.4	Confusion Between Methods and Processes	322
8.4.5	Duplication of Existing Activities	323
8.4.6	Unclear Definition	323
8.4.7	Unclear Improvements	323
8.4.8	Difficult to Implement	323
8.4.9	Method Evolution and Confusion	323
8.4.10	Market Push	324

---

8.5	No Method is an Island . . . . .	324
8.6	The Challenges . . . . .	324
	Bibliography . . . . .	325
<b>9</b>	<b>PLM and the Internet of Things . . . . .</b>	<b>327</b>
9.1	This Chapter . . . . .	327
	9.1.1 Objective . . . . .	327
	9.1.2 Content . . . . .	327
	9.1.3 Relevance . . . . .	328
9.2	Introduction to the IoT . . . . .	328
9.3	Components of the IoT . . . . .	328
	9.3.1 The Internet, a Communications Network . . . . .	328
	9.3.2 IoT Devices . . . . .	329
	9.3.3 Smart Products, Intelligent Products . . . . .	330
	9.3.4 Data Transmitted Over a Network . . . . .	331
	9.3.5 Mobile Technology . . . . .	331
	9.3.6 Location Detection Technology . . . . .	332
	9.3.7 Cloud . . . . .	332
	9.3.8 Cybersecurity . . . . .	332
	9.3.9 The Internet of Things . . . . .	332
	9.3.10 IoT Platforms . . . . .	333
9.4	Big Data . . . . .	334
	9.4.1 To In Introduction to Big Data . . . . .	334
	9.4.2 Three Contexts of Big Data . . . . .	335
	9.4.3 Commercial Big Data . . . . .	336
	9.4.4 Social Media and General Internet Big Data . . . . .	336
	9.4.5 Industrial Big Data . . . . .	336
	9.4.6 Big Data across the Product Lifecycle . . . . .	337
9.5	Analytics . . . . .	337
	9.5.1 Typical Benefits of Analytics . . . . .	338
	9.5.2 The Value of Big Data . . . . .	339
	9.5.3 Lifecycle Application Areas of Big Data . . . . .	340
9.6	Big Data Issues and Success Factors . . . . .	341
	9.6.1 Questions about Big Data . . . . .	341
	9.6.2 Typical Issues with Big Data . . . . .	341
	9.6.3 Typical Issues with Big Data Projects . . . . .	342
	9.6.4 Big Data Success Factors . . . . .	343
9.7	PLM, IoT and Big Data . . . . .	344
9.8	The Opportunity of the Internet of Things . . . . .	346
	9.8.1 Financial Opportunity of the IoT . . . . .	346
	9.8.2 Strategic Opportunity of the IoT . . . . .	346
9.9	Potential Benefits with the Internet of Things . . . . .	347
	9.9.1 Benefits for the Manufacturer . . . . .	347
	9.9.2 Benefits for the Product User . . . . .	348
	9.9.3 IoT Impacts across the Lifecycle . . . . .	348

9.10	IoT Issues and Success Factors . . . . .	350
9.10.1	Issues with the IoT . . . . .	350
9.10.2	Typical Issues with IoT Projects . . . . .	350
9.10.3	Success Factors . . . . .	351
9.10.4	IoT, Big Data and the PLM Initiative . . . . .	352
	Bibliography . . . . .	352
<b>10</b>	<b>PLM, Facilities and Equipment, Industry 4.0 . . . . .</b>	<b>353</b>
10.1	This Chapter . . . . .	353
10.1.1	Objective . . . . .	353
10.1.2	Content . . . . .	353
10.2	Introduction to Industry 4.0 . . . . .	354
10.2.1	Background—Germany . . . . .	354
10.2.2	Background—Elsewhere . . . . .	355
10.2.3	Opportunities with Industry 4.0 . . . . .	356
10.2.4	Japan—Society 5.0 . . . . .	357
10.2.5	Take-Away . . . . .	357
10.3	Industry 4.0 Technologies and Buzzwords . . . . .	357
10.3.1	Technologies of Industry 4.0 . . . . .	357
10.3.2	The Industrial IoT and Industry 4.0 . . . . .	359
10.4	Back to the PLM Grid . . . . .	360
10.4.1	PLM Applications . . . . .	360
10.4.2	Facilities and Equipment . . . . .	362
10.4.3	Relationship with PLM . . . . .	363
10.5	Industry 4.0 Facilities and Equipment Vision . . . . .	364
10.5.1	An Intelligent Factory . . . . .	364
10.5.2	A Connected Factory . . . . .	364
10.5.3	A Digital Factory . . . . .	365
10.5.4	An Augmented Reality Factory . . . . .	365
10.5.5	Big Data and Analytics . . . . .	365
10.5.6	In-Charge Factory . . . . .	366
10.5.7	Adaptable, Flexible Factory . . . . .	366
10.5.8	Secure, Protected Factory . . . . .	366
10.5.9	Artificial Intelligence Augmented Factory . . . . .	366
10.5.10	Additive Manufacturing . . . . .	367
	Bibliography . . . . .	367
<b>11</b>	<b>PLM and the Digital Twin . . . . .</b>	<b>369</b>
11.1	This Chapter . . . . .	369
11.1.1	Objective . . . . .	369
11.1.2	Content . . . . .	369
11.2	Of Representations and Descriptions . . . . .	370
11.2.1	Digital Twin . . . . .	370
11.2.2	A Definition of Digital Twin . . . . .	370

11.2.3	Representations . . . . .	370
11.2.4	A Description . . . . .	371
11.3	Changing Representations and Descriptions . . . . .	371
11.3.1	In the 1890s . . . . .	371
11.3.2	In the 1970s . . . . .	373
11.3.3	In the 1990s . . . . .	376
11.3.4	In the 2020s . . . . .	377
11.4	Representations and the PLM Grid . . . . .	380
11.5	Digital Model of the Product . . . . .	380
11.5.1	From Digital Model to Digital Twin . . . . .	383
11.6	Digital Twin. Representation, Concept, Definition . . . . .	385
11.6.1	Digital Twin: A Concept . . . . .	386
11.6.2	Definitions of Digital Twin . . . . .	386
11.7	Digital Twin Applications and Use Cases . . . . .	387
11.8	Benefits of Digital Twins . . . . .	390
11.9	Issues with Digital Twins . . . . .	390
11.9.1	Early Stage Issues . . . . .	390
11.9.2	Scope, Size and Complexity Issues . . . . .	391
11.9.3	Data Issues . . . . .	392
11.9.4	Application Issues . . . . .	392
11.9.5	Model Issues . . . . .	392
11.9.6	Product Issues . . . . .	393
11.9.7	Security Issues . . . . .	393
11.9.8	Legal Issues . . . . .	393
11.10	The Digital Twin Project in the PLM Initiative . . . . .	393
11.10.1	Digital Twin Feasibility Study . . . . .	394
11.11	Challenges for Digital Twin Projects . . . . .	395
11.11.1	Business Challenges . . . . .	396
11.11.2	Cost Challenges . . . . .	396
11.11.3	Organisational Challenges . . . . .	397
11.11.4	People Challenges . . . . .	397
11.11.5	Project Governance and Management Challenges . . . . .	397
11.11.6	Change Management Challenges . . . . .	398
11.11.7	Data Management and Quality Challenges . . . . .	399
11.11.8	Product Challenges . . . . .	399
11.12	Success Factors for Digital Twin Projects . . . . .	399
	Bibliography . . . . .	401
<b>12</b>	<b>PLM and Digital Threads . . . . .</b>	<b>403</b>
12.1	This Chapter . . . . .	403
12.1.1	Objective . . . . .	403
12.1.2	Content . . . . .	403
12.2	Digital Thread . . . . .	404
12.2.1	The Concept of a Thread . . . . .	404
12.2.2	The PLM Grid and the Digital Thread . . . . .	405

12.2.3	Applications, Business Processes, People . . . . .	405
12.2.4	Provenance of the Digital Thread Term . . . . .	409
12.2.5	Digital Thread Definitions . . . . .	410
12.3	Without a Digital Thread . . . . .	410
12.3.1	Overview . . . . .	410
12.3.2	In the Detail . . . . .	412
12.4	Benefits of the Digital Thread . . . . .	413
12.5	Examples of Digital Threads . . . . .	413
12.6	Issues with the Digital Thread . . . . .	413
12.7	The Digital Thread Project in the PLM Initiative . . . . .	414
12.8	Perils of a Digital Thread Project . . . . .	417
12.9	Success Factors for a Digital Thread Project . . . . .	418
	Bibliography . . . . .	419
<b>13</b>	<b>PLM and Organisational Change Management . . . . .</b>	<b>421</b>
13.1	This Chapter . . . . .	421
13.1.1	Objective . . . . .	421
13.1.2	Content . . . . .	421
13.1.3	Relevance of OCM in PLM . . . . .	422
13.2	Definitions and Introduction . . . . .	423
13.2.1	Definitions . . . . .	423
13.2.2	Benefits of OCM . . . . .	424
13.2.3	Incremental and Transformational Change . . . . .	424
13.2.4	Equation for Change . . . . .	425
13.2.5	Resistance to Change . . . . .	427
13.2.6	Pre-requisites for Organisational Change . . . . .	429
13.2.7	KPIs for Organisational Change . . . . .	430
13.2.8	The Importance of OCM in the PLM Environment . . . . .	430
13.3	Participants in Change . . . . .	431
13.3.1	Benefits of the Change to PLM . . . . .	431
13.3.2	People Who Make Change Happen . . . . .	432
13.3.3	People in the Product Lifecycle . . . . .	434
13.3.4	Roles . . . . .	438
13.4	Reality in a Typical Company . . . . .	439
13.4.1	Generic Issues with Change . . . . .	439
13.4.2	OCM Interaction with Company Resources and Initiatives . . . . .	439
13.5	OCM Activities in the PLM Initiative . . . . .	440
13.5.1	Projects Related to OCM . . . . .	440
13.5.2	Plan the Change Project . . . . .	441
13.5.3	Communication . . . . .	442
13.5.4	Learning and Training . . . . .	445
13.5.5	The Reward System . . . . .	447

---

13.6	Learning from Experience . . . . .	448
13.6.1	Tips from the Trenches . . . . .	448
13.6.2	Be Realistic . . . . .	449
13.6.3	Pitfalls of Organisational Change . . . . .	450
13.6.4	Top Management Role with OCM . . . . .	450
	Bibliography . . . . .	452
<b>14</b>	<b>PLM and Project Management . . . . .</b>	<b>453</b>
14.1	This Chapter . . . . .	453
14.1.1	Objective . . . . .	453
14.1.2	Content . . . . .	453
14.1.3	Relevance . . . . .	454
14.2	Definitions and Introduction . . . . .	454
14.2.1	Definitions . . . . .	454
14.2.2	Characteristics of Projects . . . . .	457
14.2.3	People in Projects . . . . .	458
14.2.4	Project Phases . . . . .	464
14.2.5	Project Management Knowledge Areas . . . . .	466
14.2.6	Project Management Tools and Templates . . . . .	466
14.2.7	KPIs for Project Management . . . . .	468
14.2.8	The Importance of Project Management in PLM . . . . .	468
14.3	Project Reality in a Typical Company . . . . .	469
14.3.1	Generic Issues with Projects . . . . .	469
14.3.2	Generic Issues with Project Plans . . . . .	471
14.3.3	Interaction with Other Activities . . . . .	471
14.4	Project Management Activities in the PLM Initiative . . . . .	472
14.4.1	Project Management and Initiative Projects . . . . .	472
14.4.2	Working with Consultants . . . . .	473
14.4.3	Reviewing Readiness . . . . .	473
14.5	Learning from Experience . . . . .	475
14.5.1	From the Trenches . . . . .	475
14.5.2	Pitfalls of Project Management . . . . .	478
14.5.3	Top Management Role with Project Management . . . . .	479
	Bibliography . . . . .	480
<b>15</b>	<b>Executive Activities in PLM . . . . .</b>	<b>483</b>
15.1	This Chapter . . . . .	483
15.1.1	Objective . . . . .	483
15.1.2	Content . . . . .	483
15.2	Ten Roles of Executives . . . . .	484
15.2.1	Maintain Awareness and Provide Vision . . . . .	484
15.2.2	Set Business Objectives and Values . . . . .	484
15.2.3	Oversee Company Governance . . . . .	485
15.2.4	Lead . . . . .	485
15.2.5	Represent and Communicate . . . . .	485

15.2.6	Ask Questions, Give Answers . . . . .	485
15.2.7	Identify and Develop Leaders . . . . .	486
15.2.8	Monitor Progress and Measure Outcomes . . . . .	486
15.2.9	Take Decisions and Corresponding Action . . . . .	486
15.2.10	Hold Accountable and Provide Recognition . . . . .	486
15.3	Executive Roles in PLM . . . . .	486
15.3.1	Roles in the Future PLM Environment . . . . .	486
15.3.2	PLM Initiative Roles . . . . .	487
15.3.3	CEO . . . . .	487
15.3.4	PLM Initiative Sponsor . . . . .	488
15.3.5	PLM Initiative Steering Committee . . . . .	488
15.3.6	PLM Initiative Leader . . . . .	489
15.3.7	Governance . . . . .	489
15.4	Executive Vocabulary . . . . .	490
15.4.1	Mission . . . . .	490
15.4.2	Objectives . . . . .	491
15.4.3	Vision . . . . .	491
15.4.4	Strategy . . . . .	491
15.4.5	Plan . . . . .	492
15.4.6	Tactics . . . . .	492
15.4.7	Policy . . . . .	492
15.4.8	Key Performance Indicators . . . . .	493
15.4.9	Coherence . . . . .	494
15.5	Objectives, Vision, Strategy . . . . .	494
15.5.1	Objectives . . . . .	494
15.5.2	Vision . . . . .	495
15.5.3	Strategy . . . . .	501
15.5.4	PLM Strategy . . . . .	513
15.5.5	Implementation Strategy . . . . .	515
15.5.6	Plan . . . . .	517
15.5.7	KPIs . . . . .	517
15.6	PLM Initiative Justification . . . . .	518
15.6.1	Time Value of Money . . . . .	521
15.6.2	NPV and ROI . . . . .	522
15.6.3	Cost Justification . . . . .	524
15.6.4	Identification of Benefits . . . . .	525
15.6.5	Project Calculations . . . . .	526
	Bibliography . . . . .	529
<b>16</b>	<b>PLM and the PLM Initiative . . . . .</b>	<b>531</b>
16.1	This Chapter . . . . .	531
16.1.1	Objective . . . . .	531
16.1.2	Content . . . . .	531
16.1.3	Relevance . . . . .	531



16.2	Definition and Introduction . . . . .	532
16.2.1	Definition . . . . .	532
16.2.2	From Components to the Initiative . . . . .	533
16.2.3	Different Company, Different Initiative . . . . .	533
16.3	Getting Started with PLM . . . . .	540
16.3.1	Middle Managers, Executives . . . . .	540
16.3.2	Company and Personal Dilemmas . . . . .	542
16.3.3	Not Progressing . . . . .	544
16.3.4	Getting to the Start Line . . . . .	544
16.4	Approaches to a PLM Initiative . . . . .	546
16.4.1	Standard Approach . . . . .	546
16.4.2	The Ten-Step Approach . . . . .	560
16.4.3	After Initiative Launch . . . . .	563
16.5	Learning from Experience . . . . .	566
16.5.1	From the Trenches . . . . .	567
16.5.2	Pitfalls for the PLM Initiative . . . . .	568
16.5.3	Examples of the PLM Dilemma . . . . .	569
16.5.4	Results of Use of the Ten-Step Approach . . . . .	572
16.5.5	Common Features of PLM Initiatives . . . . .	574
16.5.6	Top Management Role in the PLM Initiative . . . . .	578
	Bibliography . . . . .	581
<b>17</b>	<b>PLM in Industry . . . . .</b>	<b>583</b>
17.1	This Chapter . . . . .	583
17.1.1	Objective . . . . .	583
17.1.2	Content . . . . .	583
17.2	Alfa Laval’s OnePLM . . . . .	584
17.2.1	The Starting Situation . . . . .	585
17.2.2	The Approach . . . . .	586
17.2.3	The Implementation . . . . .	587
17.2.4	The Result, Benefits . . . . .	589
17.2.5	Next Steps . . . . .	590
17.2.6	Lessons Learned . . . . .	591
17.3	PDM Implementations . . . . .	593
17.3.1	An Electronics Industry Company . . . . .	593
17.3.2	An Automotive Industry Company . . . . .	597
17.3.3	An Engineering Industry Company . . . . .	601
17.3.4	An Aerospace Industry Company . . . . .	606
17.3.5	Summary . . . . .	610
	Bibliography . . . . .	611
<b>18</b>	<b>Closing Thoughts . . . . .</b>	<b>613</b>



# Product Lifecycle Management (PLM)

# 1

## 1.1 What Is PLM?

### 1.1.1 Definition of PLM

Product Lifecycle Management (PLM) is the business activity of managing, in the most effective way, a company's products all the way across their lifecycles; from the very first idea for a product all the way through until it is retired and disposed of.

PLM is the management system for a company's products. It doesn't just manage one of its products. It manages, in an integrated way, all of its parts and products, and the product portfolio. PLM manages the whole range, from individual part through individual product to the entire portfolio of products.

At the highest level, the objective of PLM is to increase product revenues, reduce product-related costs, maximise the value of the product portfolio and maximise the value of current and future products for both customers and shareholders.

### 1.1.2 Definition of the PLM Initiative

The PLM Initiative of a company is an initiative with two objectives. The first of these is to improve the product-related performance of the company (Fig. 1.1). The other objective is to put in place, or to improve, the capability to manage products across their lifecycles.

Whereas PLM is an ongoing endeavour, a PLM Initiative is a temporary endeavour. Most companies will have a PLM Initiative at some time between 2020 and 2025.

Rate of introduction of new products	+100%	Lifecycle control over products	100%
Revenues from extended product life	+25%	Lifecycle visibility over products	100%
Costs due to recalls, failures, liabilities	-75%	Part reuse factor	x 7
Revenues from new services on existing products	+40%	Cost of materials and energy	-25%
Number of significantly innovative new products	x 3	Recycling of products	+90%
Development time for new products	-50%	Product traceability	100%

**Fig. 1.1** Typical targets of a PLM Initiative

### 1.1.3 A Paradigm

The title of this book refers to PLM as a twenty-first century paradigm. A paradigm is a generally agreed and shared conceptual structure that people use to work with a complex subject. It's a simple picture that helps them think about, describe, analyse and communicate about the subject. In this book, the "complex subject" that is addressed is the management of a company's products.

A paradigm is questioned and tested in everyday work and by everyday experience. A paradigm shift occurs when the majority of people find, through everyday experience and analysis, that the existing paradigm no longer fits to the practical reality of the subject.

#### 1.1.3.1 The Paradigm Before PLM

The PLM Paradigm emerged in 2001. The previous paradigm for the management of a company's products was departmental:

- The Marketing Department decided which products were needed by the market
- The Engineering Department designed them
- The Manufacturing Department produced them
- The After-Sales Department supported them.

This departmental paradigm was generally agreed and shared for most of the twentieth century. The reasoning behind it was that the specialists in a department are the best equipped to carry out the activities of that function. For example, specialists in the Engineering Department were believed to be best equipped to carry out Engineering activities. The logic behind this was that engineers learn about these activities at school or university, are further trained about them, are hired to do them, learn about them from Engineering colleagues, and practice them for years in the company. So who could do them better?

Over time, though, this reasoning and belief in departmental ability implicitly extended so that each department didn't just carry out activities for which it had specialist functional know-how. It went much further and decided everything about its operations. For example, each department decided independently how to organise its activities, its documents and its data, and its computer systems. Even though, for example, Marketing specialists aren't specialists in organising activities, any more than Engineering specialists are specialists in IS.

With time, the departmental approach led to an environment of departments working independently, interdepartmental barriers, incompatibilities at departmental borders, waste, gaps, contradictory versions of the same data, information silos, islands of automation, overlapping networks, duplicate activities, serial work, ineffective fixes and product recalls. The end result was long product development and support cycles, customers having problems with products, reduced revenues and higher costs. These anomalies showed that something was wrong with the departmental paradigm for the management of a company's products.

A paradigm shift resulted. In 2001, a new paradigm for the management of a company's products, the PLM Paradigm, emerged. It will be described in Sect. 1.5, after brief introductions to this chapter, and the acronym and scope of PLM.

---

## 1.2 This Chapter

### 1.2.1 Objective

The objective of the first chapter of this book is to provide an introduction to PLM, answering the questions: "What is PLM?"; "Why PLM?"; "When did PLM appear"; and "Where is PLM used?" The answers to these questions will help those working with PLM in a company, including those involved in a company's PLM Initiative, to understand the basics of PLM and why it's so important. It will allow them to add more value and participate more fully in the PLM Initiative and PLM activities. This chapter also aims to give students, for whom this book is a course book, a basic understanding of PLM and its importance in industry.

### 1.2.2 Content

The first part of the chapter gives definitions of PLM and a PLM Initiative. The second part of the chapter looks at the meaning of the letters P, L and M in the PLM acronym. The third part addresses the scope of PLM. It introduces the PLM Grid, describes activities within the scope of PLM and identifies the resources managed in PLM. The fourth part of the chapter describes the PLM Paradigm, detailing concepts, consequences and corollaries. The fifth part looks at the potential benefits, strategic and operational, of PLM and a PLM Initiative. The sixth part shows how PLM has spread since its emergence in 2001. As of 2022, it's used throughout manufacturing industry and throughout the world. The seventh and final part of the chapter looks at the problems that PLM solves and the opportunities it enables.

#### 1.2.2.1 Skills

From this chapter, students who've been assigned the book for coursework will gain a basic understanding of PLM, a PLM Initiative and the PLM Paradigm. They'll find out about the meaning of the PLM acronym. They'll understand the scope of PLM.

They'll know about the problems that PLM addresses. They'll see how PLM has spread throughout industry and across the world. They'll learn about the benefits of PLM. They'll be able to explain, communicate and discuss about PLM.

### **1.2.3 Relevance**

People starting to work with PLM in a company are likely to ask questions like: "What is PLM?"; "Why PLM?"; "When did PLM appear?"; and "Where is PLM used?" They'll find the answers in this chapter. It will enable those working in activities across the product lifecycle to rapidly understand PLM. After they've read the chapter, they should understand the PLM Paradigm and its essential characteristics and concepts. They'll know about the operational and strategic benefits of PLM. They'll be able to work more effectively in PLM activities.

---

## **1.3 The P, L and M of PLM**

### **1.3.1 The P of PLM**

#### **1.3.1.1 Importance**

The product is important. Whether it's a chair, a beverage, an aircraft, some software or an anaesthetic, it's the product, and perhaps some related services, that the customer wants. The product is the source of company revenues. Without a product, the company doesn't need to exist and won't have any customers. Without a product, there won't be any related services. The product is important! The company generates revenues from an ongoing stream of innovative new and upgraded products. Great products make it the leader in its industry sector. Great products lead to great profitability.

#### **1.3.1.2 Range of Products**

There's a huge range of products in the world. There are tangible products, products you can touch, products such as a computer and a car. And there are intangible products such as software, insurance policies and mortgages. There are products as diverse as an Airbus A380 and a dollar bill, a book and a beverage.

Products come in all sorts of shapes and sizes. The movement of a Swiss watch may be little longer and wider than a postage stamp, and only a few millimetres in thickness. A postage stamp is even smaller. Many other products are much larger. For example, an Airbus A380 is 73 m long, with a wingspan of nearly 80 m.

A product may actually be a service. A product can also be a package of services, or a bundle of products and services, or a solution containing several products, or a solution containing products and services.

The product is often more than what seems, at first glance, to be the product. Product packaging is often a part of the product. So is product labelling.

The product may include wires and plugs that connect it to the outside world. The product may include product literature, such as user documentation or regulatory documentation. The product may be a six-pack or a single can. If it's a six-pack, it may have additional packaging, but the product you drink is the same as if it's a single item. The delivery mechanism may be part of the product. For example, inside the packaging of an anaesthetic may be a sterile syringe.

A company's products may have been developed by the company itself. Or they may have been acquired as a result of merger and acquisition (M&A) activity.

### 1.3.1.3 Range of Number of Parts

A company's product may be made of many assemblies and thousands of parts or components or constituents or ingredients depending on the type of product. An assembly may also be made of a large number of parts. These assemblies and parts could be made by the company itself, or could be the products of other companies, its suppliers. Many products contain industrial components (products) of various types, such as hardware, software, electrical, electronic and chemical. Many products also contain other types of components, such as agricultural, forestry and fishery products.

As Fig. 1.2 shows, many products contain a lot of parts. Many companies have hundreds or thousands of products each of which may contain different parts. All of these need to be managed. Whatever the product, PLM is the management system for a company's products and parts.

## 1.3.2 The L of PLM

There are five phases in the product lifecycle (Fig. 1.3). In each of these five phases, the product is in a different state. During the ideation phase, the product is just an idea in people's heads. During the definition phase, the ideas are being converted into a detailed description. By the end of the realisation phase, the product exists in its final form (e.g. as a car) in which it can be used by a customer. During the use/support phase, the product is with the customer who is using it. Eventually the product gets to a phase in which it's no longer useful. It's retired by the company and disposed of by the customer. It may be recycled by the customer or the company or a third party.

**Fig. 1.2** Typical number of parts, or ingredients, in a product

<i>Product</i>	<i>Typical number of parts</i>
Deodorant	20
Sandwich	30
Shampoo	50
Watch	300
Machine tool	2000
Car	25000
Aircraft	400000
Space shuttle	2000000
Software (lines of code)	20000000