Decision Engineering

John Stark

Product Lifecycle Management

Volume 1: 21st Century Paradigm for Product Realisation

Third Edition

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Preface

This is the third edition of Product Lifecycle Management: Paradigm for 21st Century Product Realisation.

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 is used in all sizes of companies, ranging from large multinational corporations to small and medium enterprises. It is applied across a wide range of industrial sectors such as discrete manufacturing, process manufacturing, distribution and service industries, as well as in research, education, military and other governmental organisations.

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 multi-level 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 US and Western Europe, engineers were predominantly men, white and white-shirted.

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

Between 1970 and 2015, for various reasons, 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 were 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. Other changes resulted from concerns about Global Warming, the environment and sustainability.

Facing so many changes, companies had to change to remain competitive. But change how? What is the new paradigm for managing products in the changed environment? Or, put another way, how should a company, its executives, managers and employees be organised and work in this new environment? And, how should a company transition from the old paradigm to the new paradigm? Or, put another way, what set of actions will a company have to execute to achieve the change? What will be in the PLM Initiative? This book answers these questions.

The new 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. 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. It is increasingly accepted that the environment of PLM is complex, and that new ways are needed to handle this complexity. And, due to technological advances, new opportunities for PLM have appeared in areas such as: Big Data; Smart Products; the Internet of Things; Knowledge Management; and SMAC (Social, Mobile, Analytics, Cloud).

This third edition of the book addresses these changing views, continuing 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 selection and structure of the content comes from two of the author's observations. First, that there are five main subject areas, the Five Pillars of PLM, in PLM and PLM Initiatives. Second, that everyone participating in a company's PLM activities should have at least a basic understanding of all five of these areas. The five areas are: business processes; product data; information systems; organisational change management (OCM) and project management. In the author's experience, most of the participants in a typical PLM Initiative will only have knowledge and experience in one or two of these areas. This imbalance in understanding of the five areas results in a lot of guesses, assumptions, misunderstandings and confusion that often leads to serious consequences for the company's PLM activities.

There are eight chapters in this book. The first two chapters provide introductions to PLM and to the PLM environment. The following five chapters provide introductions to the five Pillars of PLM. The final chapter gives an introduction to the PLM Initiative. Each of the five Pillars, for example, OCM, is a huge area in itself. There are already many books addressing each of these subjects. The intention of these five chapters is not to repeat everything known about the subject. Instead, it is to provide, for the specific environment of PLM, an introduction that will enable people to start to work effectively in PLM activities. The book can be thought of as "PLM 101". It will be a good onboarding tool for anyone in a company working on PLM activities. It will also be useful for undergraduate and postgraduate university students starting to learn about PLM.

The author has worked with more than two hundred companies of many sizes, and in many industries, during the emergence and growth of PLM. Sharing the resulting experience and knowledge meets the innate 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.

Contents

Chapter 1
Product Lifecycle Management

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 on-going endeavour, a PLM Initiative is a temporary endeavour. Most companies will have a PLM Initiative at some time between 2015 and 2020.

J. Stark, *Product Lifecycle Management*, Decision Engineering,
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Fig. 1.1 Typical targets of a PLM initiative

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

1.1.3 A 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 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 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.

1.1.4 Definition of the PLM Paradigm

The PLM paradigm is that a business-oriented, formally-defined, lifecycle, holistic, digital, joined-up and product-focused approach must be taken to the management of a company's products. This paradigm, and its consequences and corollaries, are addressed in this book.

However, two examples are given here to illustrate the paradigm shift:

- In the PLM Paradigm, the activities of managing a company's products must be defined and documented in cross-functional business processes across the product lifecycle. (In the previous paradigm, each department defined its own activities independently of the other functions. And often the activities weren't formally documented.)
- In the PLM Paradigm, a cross-functional product data management (PDM) system manages product data across the product lifecycle. (In the previous paradigm, each department managed its own data independently of the other departments.)

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?" This 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 participate more fully in the PLM Initiative and PLM activities. This chapter also aims to give students a basic understanding of PLM and its importance in industry.

1.2.2 Content

The first part of the chapter gives definitions of PLM, a PLM Initiative, and the PLM Paradigm. 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 2015, 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 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 on-going 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. 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. 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 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.

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

Fig. 1.2 Typical number of parts, or ingredients, in a 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 imagination 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 (for example, 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.

The specific activities that take place across the lifecycle vary from one industry sector to another. As a result, companies in a particular industry may have a view of

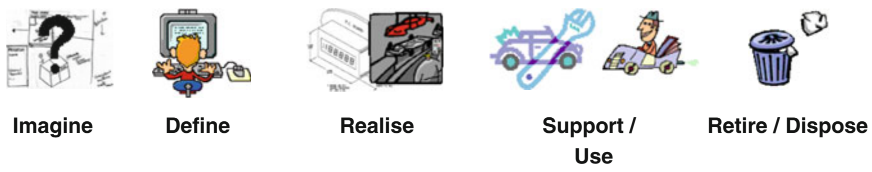


Fig. 1.3 The 5 phases of the product lifecycle

the product lifecycle that is specific to their industry. However, whatever the specifics of a particular company or industry, its activities can be mapped, in some way, to the five phases of the product lifecycle shown in Fig. 1.3.

There's nothing new in the concept of a lifecycle. In 1599, Shakespeare described a lifecycle when he wrote of the seven ages of man (the infant, schoolboy, the lover, a soldier, the justice, the lean and slippered pantaloon, second childhood).

1.3.2.1 Related Lifecycles

Manufacturers and users of products may have different views of the lifecycle. As seen by the user of the product, there are five phases in a product's lifecycle: imagination; definition; realisation; use; disposal. As seen by a manufacturer of a product, there are also five phases in a product's lifecycle: imagination; definition; realisation; support; retirement.

From the Marketing viewpoint there are market-oriented lifecycles. A four-stage example is product introduction, growth, maturity and decline. A five-stage example is product development, market introduction, market growth, market maturity and sales decline. Different approaches to the product's identity, pricing and sales strategy may be taken in different stages.

And, from the Environmental viewpoint, there's another lifecycle. A natural resource (such as an ore, or oil) is extracted from the earth, the resource is processed, the processed resource is used in the manufacturing of a product, the product is used, and when the product is no longer needed, the resource/waste is managed. It may be reused, recycled or disposed of.

1.3.3 The M of PLM

Management of products includes activities such as organisation and co-ordination of product-related resources, decision-taking, setting objectives and control of results. A product must be managed in all phases of the lifecycle to make sure that everything works well, and that the product makes good money for the company.

The product needs to be managed when it's an idea. Product ideas need to be managed to make sure, for example, that they aren't lost or misunderstood.

The product needs to be managed when it's being defined. For example, a product development project has to be managed to be sure the product meets customer requirements.

The product needs to be managed when it's being realised. For example, it's important that the correct version of the definition is used during production.

The product needs to be managed when it's in use. For example, the product must be correctly maintained, taking account of its serial number, production date, previous upgrades, changes in the market and technical evolution.

managing a well-structured and valuable Product Portfolio
maximising the financial return from the Product Portfolio
managing products across the lifecycle
managing product innovation, development, support and disposal projects effectively
providing control and visibility over products throughout the lifecycle
managing feedback about products from customers, products, field engineers and the market
effectively managing product requirements
enabling collaborative work with design and supply chain partners, and with customers
managing product-related processes so that they are coherent, joined-up, effective and lean
capturing, securely managing, and maintaining the integrity of product definition information
making product definition information available where it's needed, when it's needed
knowing the exact characteristics, both technical and financial, of a product throughout its lifecycle

Fig. 1.4 Some activities within the scope of PLM

The product needs to be managed at disposal time. Care has to be taken to make sure that poisonous components and toxic waste from the product don't get anywhere near sources of drinking water.

It's sometimes said that PLM is about managing the product throughout its lifecycle, "from cradle to grave" of "from sunrise to sunset". However, both of these phrases miss the earliest part of the lifecycle. PLM manages the product "from dawn to dusk".

1.4 The Scope of PLM

1.4.1 Activities in the Scope of PLM

PLM is a high-level business activity. All of the lower-level product-related activities of a company are united under the PLM umbrella. Figure 1.4 shows some of these activities.

1.4.2 The PLM Grid

The scope of PLM is shown in the PLM Grid (Fig. 1.5), a 5 × 10 grid or matrix. On the horizontal axis are the five phases of the product lifecycle. On the vertical axis are the ten components (data, applications, activities, etc.) that have to be addressed when managing a product across the lifecycle.

The PLM Grid helps show why the environment of the product can be complex and difficult to manage. The scope of the environment is broad. Many subjects are addressed, ranging from methods for identifying ideas for new products, through organisational structure, to end-of-life recycling equipment. The scope is wide, but that reflects the reality of managing products.

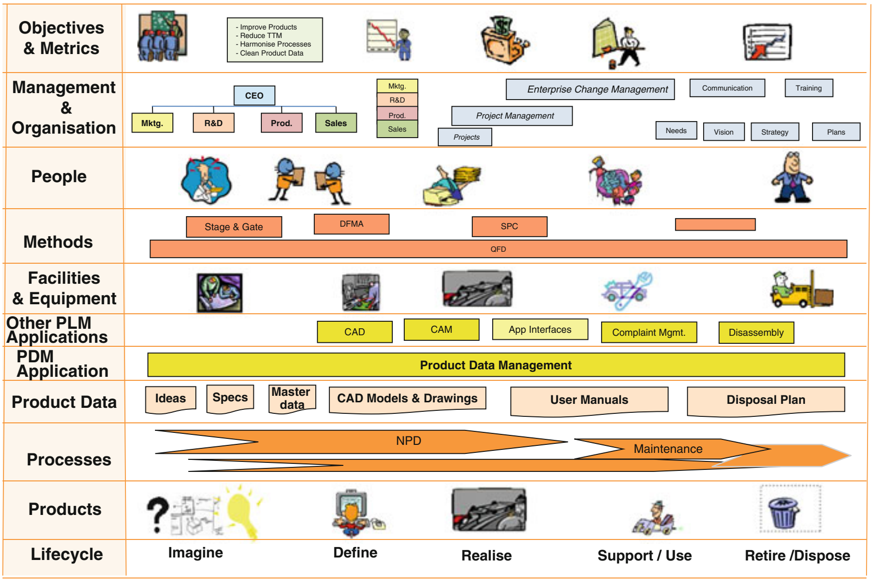


Fig. 1.5 The PLM grid

1.4.3 Resources in the Scope of PLM

Ten components are shown on the PLM Grid. They have to be managed across the five phases of the product lifecycle.

1.4.3.1 Objectives and Metrics

The company's objectives for PLM drive all its PLM activities. The PLM objectives express at a high level what's expected from PLM. PLM helps achieve improvements in many areas, such as financial performance, time reduction, quality improvement and business improvement. Metrics, also known as Key Performance Indicators (KPIs), help an organisation to set targets for its future activities, and to measure progress (Fig. 1.6). In the area of financial performance, for example, possible metrics and targets could be to increase the value of the product portfolio by 20 %, or to reduce costs due to recalls, failures and liabilities by 75 %.

number of new products per year	% of information on electronic media	cost of rework ($)
cost of IS as % of company sales	new product revenue (% of total)	number of patents
Return On Innovation	% of business processes defined	number of customers
number of projects completed per year	value of product portfolio ($)	Time To Market (months)
number of defects per product family	R&D spend (% of revenues)	level of part reuse

Fig. 1.6 Examples of KPIs in the PLM environment

1.4.3.2 Organisation and Management

In the PLM environment, there are many resources to manage, and high volumes of many of these resources. And, as if the wide scope and high volumes didn't make it difficult enough, there are complex and changing relationships to manage between products, components and customers. Organisational structures, strategies and plans must be put in place to make all the resources and activities manageable, and to meet the objectives (Fig. 1.7). Effective organisation and management of resources is all-important for PLM. Just acquiring good resources, such as IS applications and people, won't lead to success. It's only when all the resources are organised and managed to achieve the objectives of PLM, that the objectives can be met.

1.4.3.3 Activities

In every company, there's a lot of activity related to the product as it's developed, manufactured, supported and retired (Fig. 1.8). In the PLM environment, the activity is organised into business processes. In many companies, between 35 and 55 % of the business processes are product-related. Many things have to happen if everything is to work well with the product. The way these things are organised into processes is important. A company has a choice. It can put in place good processes, and do the right things well. Or it can do things badly.

1.4.3.4 People

It takes many people to develop and support a product throughout its lifecycle (Fig. 1.9). No product is made or managed without people. The company has a

departmental	flat	functional
geographical	hierarchical	hybrid
matrix	project	product-focused
pyramid	team	virtual

Fig. 1.7 Examples of organisations in the PLM environment

Idea Management	New Product Development	Engineering Change Management
Program Management	Configuration Management	Intellectual Property Management
Product Risk Management	Product Complaint Management	Product Obsolescence Management

Fig. 1.8 Examples of business processes in the PLM environment

business analyst	cost accountant	course developer	designer
database administrator	field engineer	disassembly worker	documentation clerk
product developer	product manager	project manager	machinist
recycling director	sales associate	service engineer	quality manager
marketing analyst	test engineer	software developer	validation engineer

Fig. 1.9 Examples of people in the PLM environment

choice. It can hire highly-skilled people, motivate them and train them to do things the best way, or it can do the opposite. Throughout the product lifecycle, people are all-important. They define the requirements for new products, develop products to meet the requirements, produce high-quality products, and support them in the field.

1.4.3.5 Product Data

Product data defines and describes the product, and the product is the source of company revenues. A company's product data represents its collective know-how (Fig. 1.10). As such, it's a major asset, a strategic resource, and should be used as profitably as possible. If there's something wrong with product data, then there will be problems with the product. And money will be lost. Throughout the product lifecycle, product data is all-important. It has to be available, whenever it's needed, wherever it's needed, by whoever needs it, throughout the product lifecycle. Getting it organised, and keeping it organised, are major challenges. Whatever the product made by a company, an enormous volume and variety of product data is needed to develop, produce and support the product throughout the lifecycle. Product data doesn't look after itself. If it's not managed, then, like anything that's not properly organised and maintained, it won't perform as required. Over time, it will slide into chaos and decay. However this has to be avoided as the slightest error with product data can have very serious consequences for the product.

1.4.3.6 Product Data Management System

A Product Data Management (PDM) system has the primary purpose of managing product data. It's one of the most important elements of the PLM environment. It can manage all the product data created and used throughout the product lifecycle. It can provide exactly the right information at exactly the right time. Throughout the product lifecycle, information is all-important. The PDM application gets this strategic resource under control, making it available, whenever it's needed, wherever it's needed, by whoever needs it.

analysis results	CAD geometry	costing data	regulations
ingredients lists	customer requirements	patent reports	engineering drawings
QA records	design specifications	disposal lists	label information
flowcharts	shop floor instructions	functional specs	failure reports
user manuals	machine libraries	wiring diagram	maintenance info
NC programs	packaging standards	parts classifications	parts lists

Fig. 1.10 Examples of product data in the PLM environment

1.4.3.7 PLM Applications

Just as there are many processes, and many types of product data, there are also many IS applications in the PLM environment (Fig. 1.11). Even in a medium-size company, there may be as many as fifty different applications in use. PLM applications help people develop and support products. Without these applications, it's unlikely that so many complex and precise products could be developed, produced and supported. PLM applications enable people to achieve performance levels that would be impossible by manual means alone.

1.4.3.8 Facilities and Equipment

Facilities and equipment are used in every phase of the product lifecycle (Fig. 1.12). They're needed to develop the product, to produce it, to maintain and service it, and to dispose of it. They affect the quality of the product, its cost and the time to develop and produce it. In total, there are thousands of different machines and tools available. One of the challenges of PLM is to identify the facilities and equipment that are most relevant to the activities on which the company wants to focus its efforts.

1.4.3.9 Methods and Techniques

To improve performance across the lifecycle in terms of parameters such as product development time, product cost, service cost, product development cost, product quality and disassembly costs, many methods and techniques have been proposed (Fig. 1.13). Examples include Concurrent Engineering, Design for Assembly (DFA), Early Manufacturing Involvement (EMI), Lean Production, Life Cycle Design (LCD), Open Innovation, Six Sigma, and Total Quality Management (TQM). Benefits typically proposed for these methods include: reduced time to market; improved quality; reduced costs; improved service; and reduced cycle time.

Requirements Management	Rapid Prototyping	Big Data Analytics	Recipe Development
CAD	Factory Simulation	QFD	Compliance Management
Idea Management	Robot Path Analysis	Process Mapping	Knowledge Management
Discovery	NC Programming	Sensor Management	Visualisation
Plastic Behaviour Analysis	BOM Management	Project Management	Collaboration
EDA	ERP	Document Management	Data Exchange

Fig. 1.11 Examples of PLM applications

aerator	vision system	crusher	extruder	fixture
fluffer	granulator	hopper	3D printer	jig
label applicator	kiln	NC milling machine	nut inserter	3D scanner
PoS kiosk	QCM monitor	robot	shredder	test rig

Fig. 1.12 Examples of equipment in the PLM environment

Activity Based Costing (ABC)	Simultaneous Engineering	Design for Sustainability (DFS)
Early Supplier Involvement (ESI)	Fault Tree Analysis (FTA)	Just In Time (JIT)
Life Cycle Assessment (LCA)	Poka Yoke	TRIZ

Fig. 1.13 Examples of methods in the PLM environment

1.4.3.10 Products

A company's products are one of its most important resources. It's the product, and perhaps some related services, that the customer wants. The product is the source of company revenues. It must be managed in all phases of the lifecycle to make sure that everything works well, and that it makes good money for the company.

1.5 The PLM Paradigm

The PLM paradigm is that a business-oriented, formally-defined, lifecycle, holistic, digital, joined-up and product-focused approach must be taken to the management of a company's products.

This contrasts with the previous Departmental paradigm. That had a technically-oriented, undefined, departmental, piecemeal, paper-based, separate and unfocused approach to the management of a company's products (Fig. 1.14).

The main concepts of the PLM Paradigm, and the resulting consequences and corollaries, are described in the next sections.

1.5.1 PLM Concepts

1.5.1.1 Business-Oriented

PLM is a business activity. It's carried out to meet business objectives of increasing product revenues, reducing product-related costs, maximising the value of the product portfolio, and maximising the value of current and future products for both customers and shareholders.

PLM Paradigm		*Previous Paradigm*
Business-oriented		Technically-oriented
Formally-defined		Undefined
Lifecycle		Departmental
Holistic		Piecemeal
Digital		Paper-based
Joined-up		Separate
Product-focused		Unfocused

Fig. 1.14 Differences between the PLM Paradigm and the previous paradigm

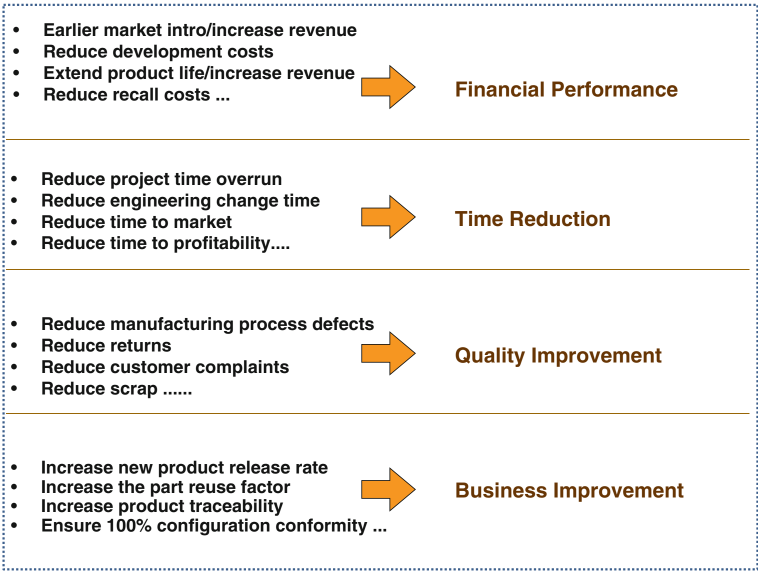


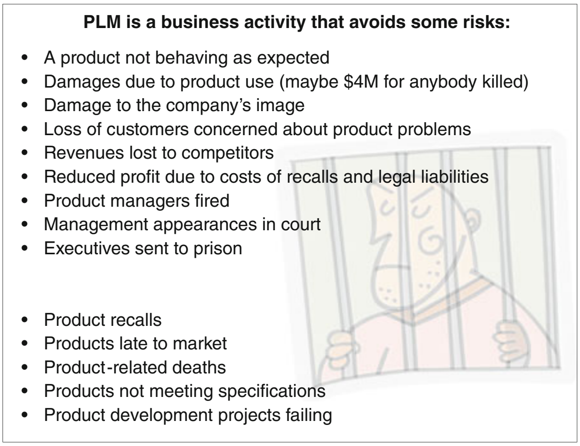
Fig. 1.15 Business objectives of PLM

In addition to business objectives related to improved financial performance, PLM has objectives related to time reduction and quality improvement (Fig. 1.15).

PLM is an activity that reduces product-related risks for the business (Fig. 1.16).

With the previous paradigm, each department implemented its own methods and techniques to support its functional activities. This led to companies having an "Alphabet Soup" of many methods and approaches (Fig. 1.17). Each of these had technical objectives (such as "design better"), not business objectives (such as "increase product revenues").

Fig. 1.16 Risk reduction with PLM



		ABC	CAD	CAE	CAM		
		CM	DFA	DFM	DFMA		
DFE	DFSS	DMU	ECM	EDM	EMI	FA	FEA
FMEA	GT	JIT	LCA	NPD	NPI	NPDI	RPS
		PDM	STEP	S&G	TRIZ		
		UML	VA	VE	XML		

Fig. 1.17 Alphabet Soup for managing a product

With the previous paradigm, companies didn't manage the product as well as they could have done, but, of course, to some extent they managed it. Managers in some departments made sure that products were sold, making money for shareholders, and enabling employees and suppliers to be paid. And in other departments, other managers made sure that new products were developed and brought to market.

1.5.1.2 Formally-Defined

Under the PLM paradigm, the way that a company manages its products across the lifecycle must be proactively designed and defined. It's formally documented in the company's Quality Manual. In addition, people are trained about PLM.

Under the previous paradigm, the way that companies managed their products didn't result from a clear, deliberate, documented plan, but as a consequence of the way the various departments organised their activities. The subject of how products were managed across the lifecycle wasn't explicitly addressed by company management. It wasn't planned. It wasn't documented. In such a situation, often nobody in the company could describe in detail how the products were managed throughout the lifecycle.

1.5.1.3 Lifecycle

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.

With PLM, people are trained to think about the product across its lifecycle. For example, engineers designing a product take account of how it will be manufactured. And how it will be disassembled and recycled. The recycling specialists keep up-to-date with environmental laws and keep development engineers informed. Together, they work out how to design products that can be disassembled quickly, and how to re-use parts in new products. People look to add value and create revenues across the lifecycle. Opportunities include developing new environment-friendly products, providing customised products, providing services to support product use, refurbishing existing products, and taking financial and environmental responsibility for products produced in low-cost countries. Experience from product operations is used in development of future products. Feedback about the use of one generation of a product helps improve future generations. Products that have reached the end of their life are disassembled, and some parts are reused in the start-of-life of new products.

Before PLM, companies didn't have an approach that managed a product continuously and coherently throughout the lifecycle. Marketing, R&D, Manufacturing, Support and other departments, such as IS and Quality, took product-related decisions separately. Products were managed by one department in early stages of their life, then by another. Often the company didn't manage the product during its use, and partially or totally lost control of the product. Sometimes a department managed the product again when the product was due for disposal. Sometimes it didn't.

Before PLM, application software was put in place departmentally. As an example, in the Engineering Department, without considering the needs of other people in the lifecycle, design engineers would buy new Computer Aided Design (CAD) software to design products faster. In the Recycling Department, recycling specialists scratched their heads and wondered what they were going to do with yet another truck-load of products too difficult to disassemble and recycle.

1.5.1.4 A Holistic Paradigm

PLM has a holistic approach to the management of a product. It's a business activity addressing not only products but also organisational structure, working methods, processes, people, information structures and information systems (Fig. 1.18). Under PLM, all of the components of the PLM Grid are taken into account when managing the product.

Fig. 1.18 PLM is holistic

Under the previous paradigm, there was a piecemeal approach to managing these components. They were managed in different unconnected ways at different times in the lifecycle with different approaches by different people. There was no overview of how they were managed.

And with activities spread out between different functional organisations, nobody had a holistic overview of the product. Product developers could see product details in their CAD system, but had no idea if customers really needed these details or even if these products were being sold. Meanwhile Product Managers looked at Sales figures, but didn't have access to the fine details of products and features, so couldn't see how these were related to sales results. Executives received impressive Word reports and good-looking PowerPoint presentations, but had no access to the underlying data that would help them take better decisions. Quality problems communicated by product users were dutifully logged in Quality databases. But often, the developers of new products couldn't access these databases, and the same problems were designed into new products.

1.5.1.5 Digital

PLM is a digital paradigm. Under the PLM paradigm, products are managed across the lifecycle with digital computers, digital information and digital communication.

In the previous paradigm, people used analogue and mechanical calculation devices, and paper-based information and communication.

1.5.1.6 A Joined-up Paradigm

PLM is "joined-up" (Fig. 1.19). With PLM, the organisation manages the product in a continuous coherent joined-up way across the lifecycle. PLM joins up many previously separate and independent activities, disciplines, functions and applications, each of which, though addressing the same product, previously had its own vocabulary, rules, culture and language. All the product-related issues are united under PLM and are addressed together in a joined-up way.

Product Development	and	Product Support
Product Infancy	and	Product End-of-Life
CAD, PDM	and	Project Portfolio Management
Product Development	and	Product Disposal
Product Assembly	and	Product Disassembly
Product Development	and	Product Liability
Product Developers	and	Customers
Product Definition	and	Environmental Issues
Product Development	and	Sustainable Development
Product Innovation	and	Mature Products
Project Portfolio Management	and	Product Portfolio Management

Fig. 1.19 PLM is a joined-up paradigm

With the previous paradigm, organisations didn't manage products in a joined-up way across the product lifecycle. Many things were done separately, in separate departments across the lifecycle. For example, product development and product support were often carried out in separate parts of the organisation even though they addressed the same products. Because they were addressed in separate parts of the organisation, the activities were carried out by different groups of people with different managers. Each group worked the way it wanted to, defined its own data and document structures, and selected its own software applications. Each group solved its own problems as best it could, adding an application here, a document there. Each group optimised its own activities, even though this might mean reducing overall effectiveness.

1.5.1.7 Focus on the Product

PLM puts the focus on "the product" (Fig. 1.20). The company's products are what the customer buys. They are the source of a company's revenues. PLM addresses the heart of the company, its defining resource, the source of its wealth, its products. That's the role of PLM, which is why PLM is so important. Products define a company. Without its products, a company wouldn't be the same. There's little in a company more important than its products, and the management of their development and use. Without those products, there will be no customers and no revenues (Fig. 1.21).

With PLM, people work top-down. They start by thinking about the portfolio of existing products and those in development, then work down through product families, platforms, and modules, to products, and then to parts. They focus on the product, which creates value, and not on the associated bits and bytes.

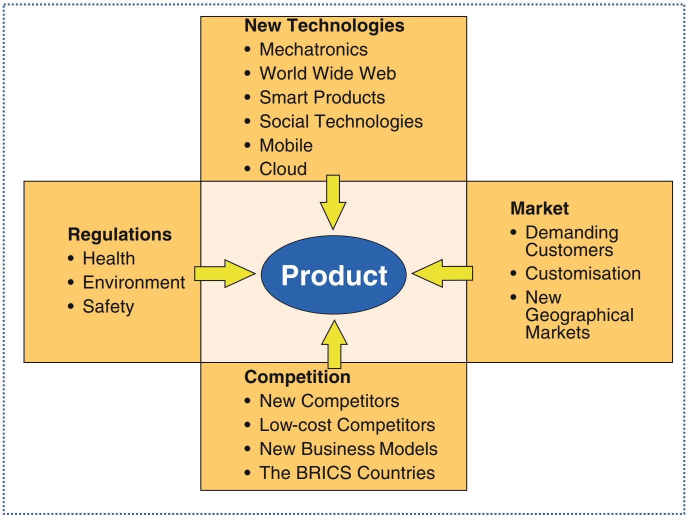


Fig. 1.20 PLM puts the focus on the product

the product is important
customers buy products
corporate revenues result from product sales
without products, there's nothing for Sales to sell
product focus and customer focus

Fig. 1.21 Importance of the product

With PLM, the rule is "focus on the product and the customer". Customers buy great products. Companies can have all the knowledge in the world about their customers, and what the customers have said, but they won't get a sale without a competitive product.

Under the previous paradigm, people would think bottom-up, starting with parts and building up to the product. After parts were developed, it would be found that they didn't fit into assemblies. So they were redesigned. Then, the assemblies were redesigned to fit together. Companies developed some parts in one CAD system then found, because of differences in CAD data representations, that they didn't fit with parts developed in other CAD systems. Engineers developed data transfer software to address the problem. They wasted time down at the level of bits and bytes, instead of focusing on the product.

1.5.2 PLM Consequences

The paradigm shift to the PLM Paradigm has important consequences for the components of the PLM Grid. Many changes result for each component. The date and order in which companies carry out these changes differs from one company to another. Some companies started making these changes soon after PLM emerged in 2001. Often, they found that they could build on experience gained with similar changes in other areas of the company.

With the PLM Paradigm, the activities of managing a company's products must be organised, defined and documented in cross-functional business processes across the product lifecycle. The processes fit into the company's Business Process Architecture. Wherever possible, tasks are run in parallel to reduce cycle times. (Under the previous paradigm, each department defined its own activities independently of the other functions. And often the activities weren't formally documented. And tasks were carried out in series.) The change to business processes is one of those for which some companies already had experience. Often they had started Business Process Re-engineering in other areas of the company in the 1990s.

With the PLM Paradigm, a cross-functional product data management (PDM) system manages product data across the product lifecycle. (Under the previous paradigm, each department managed its own data independently of the other departments.)

With the PLM Paradigm, product data (the data that defines a company's products) is a company asset. Content, format and structure are detailed and documented in a product data model. Product data is seen as a form of Intellectual Property. It's a valuable strategic resource. The product data model fits into the Enterprise data model. (Under the previous paradigm, the concept of product data didn't exist. There was Marketing data, Engineering data and Manufacturing data. The data that defined a product was in various documents created independently in each department. Sometimes it was on paper, sometimes it was electronic. Sometimes it was in a "Drawing Store", sometimes in a desk drawer, sometimes on a C: or F: drive).

With the PLM Paradigm, the software applications used to support product-related activities across the lifecycle must fit into an overall company IS Architecture. (Under the previous paradigm, each department selected its own applications with the objective of improving departmental performance.)

With the PLM Paradigm, the various methods (such as DFA and LCA) used to support product-related activities across the lifecycle must fit into the overall company Business Process and IS Architectures. (Under the previous paradigm, each department selected and implemented its methods independently.)

With the PLM Paradigm, Key Performance Indicators are business-oriented. Time to Market is an example. Another example is "% revenues from products less than 5 years old". (Under the previous paradigm, KPIs were departmental. A typical KPI was "Headcount in Engineering".)

With the PLM Paradigm, product architecture, the portfolio of products, platform products, product families, and the relationship of a product to other products are all-important. (Under the previous paradigm, each new product was developed from scratch. Its functionality was paramount. Its structure, relationship with other products, and degree of reuse of existing parts were seen as minor issues.)

With the PLM Paradigm, people work in Product Family Teams, and are focused on the success of the products of their family. (Under the previous paradigm, people were hired, trained and worked on a departmental basis. Their activities were decided by departmental managers. They could be promoted within the department. They could aim for a corner desk in the department's offices. They were focused on departmental issues.)

With the PLM Paradigm, companies use the best resources across the lifecycle, independent of their gender, race and religion. (Under the previous paradigm, in the US and Western Europe, engineers were nearly all male, and white.)

With the PLM Paradigm, Global Products give billions of people the possibility to benefit from products to which they previously had no access. Global Products are manufactured products that can be purchased and used worldwide, and are maintained and supported worldwide. Often they're developed and engineered in many locations, and assembled from materials and parts manufactured in many locations. Examples include airplanes, cars, machines, watches, clothes, soft drinks, pharmaceutical products, soap, computer software, computer games, and consumer electronics products, such as tablets, televisions and smartphones. Billions of people can benefit from products to which they previously had no access. (Under the previous paradigm, although many companies were international, or multinational, very few offered products throughout the world.)

With the PLM Paradigm, Organisation and Management are business-oriented, formally-defined, lifecycle, holistic, digital, joined-up, and product-focused. (Under the previous paradigm, they were technically-oriented, undefined, departmental, piecemeal, paper-based, separate, and unfocused.)

1.5.3 PLM Corollaries

Several corollaries follow on from the PLM Paradigm.

Under the previous paradigm, product-related issues weren't considered to be a subject for management. With PLM, top managers understand and can formulate the need for effective product lifecycle management. They define the key metrics. And how the activity will be managed.

Under the previous paradigm, people thought functionally about the company. A Marketing VP, an Engineering VP and a Manufacturing VP would report to the CEO. Managers of product lines would report in through a matrix. With PLM, a Chief Product Officer (CPO) has the responsibility for all the products across the lifecycle. The CPO reports to the CEO. So do the Chief Financial Officer (CFO) and the Chief Information Officer (CIO). Product Managers report to the CPO.

Under the previous paradigm, people in Marketing and Sales would refer to the product portfolio. This was the portfolio of existing products. Meanwhile, people in Engineering would refer to the project portfolio. This was the portfolio of projects to develop new products. With PLM, everyone in the lifecycle refers to the integrated portfolio which contains both the existing products and those in the pipeline. And the value of the integrated portfolio is a key KPI.

Under the previous paradigm, the rule was "listen to the Voice of the Customer". With PLM, the rule is "listen to the Voice of the Product as soon as possible". Get the product to report back about how it's working, for example using the Internet of Things (IoT). And, of course, don't forget to listen to the Voice of the Customer.

Under the previous paradigm, people would carry out a Customer Survey to find out what customers thought of existing and future products. With PLM, people think Customer Involvement. Using technologies such as mobile telephony, GPS, Radio Frequency Identification (RFID) technology and IoT technology, they exchange information directly with a customer who's using the product. Getting feedback from a customer at the actual time of use provides more valuable information than a survey form.

1.6 Benefits of PLM

With its focus on the product, companies are looking for PLM to provide strategic and operational benefits.

1.6.1 Strategic Benefits

PLM improves the activity of product development, without which a company won't survive. The source of future revenues for a company is the creation of new products and services. PLM is the activity that enables a company to grow revenues by improving innovation, reducing time-to-market for new products, and providing superb support and new services for existing products. PLM helps bring new products to market faster. It's important for a company to bring a product to market quickly. Otherwise the customer will choose a competitor's product before the company's product gets to market.

PLM enables a company to reduce product-related costs. It's important to reduce product costs. Otherwise the customer will choose a competitor's product that costs less than the company's product. Product-related material and energy costs are fixed early in the product development process. PLM provides the tools and knowledge to minimise them. And PLM helps cut recall, warranty and recycling costs that come later in the product's life.

PLM enables better support of customers' use of products. It's important for a company to support customers' use of its product. Otherwise they may stop using the company's product. They may start to use a competitor's product instead.

PLM enables the value of a product to be maximised over its lifecycle. With accurate, consolidated information about mature products available, low-cost ways can be found to extend their revenue-generating lifetimes.

PLM gets products under control across the lifecycle. As a result, managers face less risk and fire-fighting. They can spend more time on preparing an outstanding future with awesome products.

1.6.2 Operational Benefits

PLM helps companies to develop and produce products at different sites. It enables collaboration across the design chain and the supply chain. PLM helps manage Intellectual Property. It helps maximise reuse of product knowledge. It helps bring together the management of products and processes, and to get processes such as engineering change management under control. It helps ensure compliance with regulations.

PLM gives transparency about what's happening over the product lifecycle. It offers managers visibility about what's really happening with products and with product development, modification and retirement projects. Without PLM, they are often faced by a huge mass of conflicting information about a product. PLM gives them the opportunity to manage better. With access to the right information, they can make better decisions.

Imagine	*Define*	*Realise*	*Support/Use*	*Retire/Recycle*
	Projects on time	Reduced energy use	Fewer failures	
	Fast time to market	Trained workers	Better customer info.	
	Data under control	Efficient machine use	Add-on modules	
	Clear processes	Less rework	More customers	
Support applications	IP under control	Green logistics	Happy customers	Lean processes
Supportive culture	Motivated people	Green production	Enable IoT application	Re-usable materials
IP under control	Clear requirements	Optimal shop layout	Services revenues up	Re-usable parts
No bureaucracy	Customisation	Less inventory	More services	Environment-correct
Clear process	Clear decisions	More part re-use	Lower service costs	New applications
Breakthrough ideas	Reduced costs	Less scrap	In-service upgrades	Disassembly time cut
Imaginative people	#1 product family	Strategic suppliers	Liability costs cut	Fewer fines
More ideas	Standards adherence	Lower material costs	Warranty costs cut	Better compliance

Fig. 1.22 Benefits from PLM in each phase of the lifecycle

PLM provides benefits throughout the product lifecycle (Fig. 1.22). Examples include getting products to market faster, providing better support for their use, and managing the end of their life better.

The benefits of PLM are measurable and visible on the bottom line (Fig. 1.23).

1.7 The Spread of PLM

PLM is used in a wide range of industries that develop, produce and support products (Fig. 1.24). It's used in discrete manufacturing, process manufacturing, distribution and service industries. It's also used in research, education, military and other governmental organisations.

Increased Revenues	*Reduced Costs*
increased number of customers	reduced energy costs
increased range of products	reduced development costs
increased sales of new products	reduced material costs
increased sales of mature products	reduced liability costs
increased product prices	reduced prototyping costs
increased range of services	reduced rework costs
increased service prices	reduced documentation costs
increased service revenues	reduced warranty costs

Fig. 1.23 Benefits of PLM translate into increased revenues and reduced costs

aerospace	apparel	automotive	beverage	chemical
consumer goods	construction equipment	defence	electrical engineering	electronics
financial services	food	furniture	life sciences	machine tool
machinery	medical equipment	mechanical engineering	petrochemical	pharmaceutical
plastics	plant engineering	rubber	shipbuilding	shoe
software	transportation	turbine	utility	watch

Fig. 1.24 Industries using PLM

PLM is used in all sizes of companies ranging from large multinational corporations to small and medium enterprises. The particular PLM requirements of companies of different sizes may differ, but the fundamental requirements don't. In companies of all sizes, products have to be managed, product data has to be managed, product development and support processes have to be managed, and product data has to be exchanged with other organisations. Applications have to be managed, and people have to be trained to work as effectively as possible with PLM.

The list of products for which PLM is used is long. It includes agricultural machinery, aircraft, beverages, cars, chemicals, computers, consumer electronics, electrical equipment, electricity, elevators, escalators, food, furniture, gas, insurance policies, machine tools, machines, medical equipment, medicines, mobile phones, mortgages, office equipment, offshore structures, pharmaceutical products, power plants, power transmission belts, processed food, refrigerators, rockets, ships, shoes, software, telecommunications equipment, telecommunications products, telephones, toys, trains, turbines, washing machines, watches, water and windows.

PLM is about "managing products across their lifecycles", and it applies to any company with a product. It applies to companies making many identical, or similar, products such as cars, machines and electronic equipment. It also applies to companies making one-of-a-kind products, and for companies such as "job shops" in which every product is customised to the customer's requirements. PLM is vital to a job shop because it provides control and visibility over each individual product. The configuration management features of PLM make sure all the information about the product is under control. And PLM keeps track of what was ordered and what was delivered, and what was done to the product after delivery to the customer.

PLM is used throughout the world. It's used in North America, South America, Asia, Australasia, Africa and Europe.

The starting point for PLM varies from one company to another. In some companies, one function may be seen as a strategically important function or may be seen as a test-bed for new approaches. In such cases, initial PLM activities often start in this function. In some companies, the selection of the starting point for PLM may depend on the requirements of other corporate initiatives. And in other companies, the choice may be a response to particular needs, or particular problems.

1.8 Overcoming Problems, Enabling Opportunities

PLM provides companies a way to overcome problems with existing products and with the development of new products. It also helps them seize the many market opportunities for products in the early twenty-first century.

1.8.1 Managing the Product Isn't Easy

Managing the product across its lifecycle isn't easy. During the development of a product, it doesn't physically exist. Not surprisingly, during that phase of life it's difficult to control. Once a product does exist, it should be used at a customer location, where again, it's difficult for a company to keep control of it.

Within a company, the responsibility for the product may change at different phases of the lifecycle. Maintaining a common coherent approach in these circumstances can be difficult and time-consuming. It becomes even more challenging in the Extended Enterprise environment. The issues are then no longer just cross-functional but also cross-enterprise. And it becomes even more challenging when a company works in different Extended Enterprises for different products. At different times the responsibility for the product may then be with many groups in different companies. They may be on several continents, in different time zones and speaking different languages.

With globalisation, management of products became even more complex. Even small and medium-sized companies faced competitors all over the world bringing out similar products, but with better cost/performance than their own. The result of the increased competition was that companies had to be more innovative, develop better products, develop them faster and develop them at lower cost. Globalisation also meant that companies had to be close to customers in many places, and to understand customer requirements and sell products in many environments. However, the situation in different countries is different. Companies have to understand and take account of these differences. For example, they have to get pricing right in many different environments. They also have to provide technical information, parts, products and service in many locations and languages. They must meet regulations in many countries. They have to coordinate the launch of new and modified products for the global marketplace.

Many questions have to be answered. For which geographical markets should we offer our products? The whole world? One continent? Several continents? Just a few countries? If so, which ones? Should we introduce a new product everywhere in the world at the same time, or introduce it first in one market, then in the others? Do we understand these markets well enough? Should we have one product for customers throughout the world? Or should we have slightly different products in each region? Where will we develop our products? In a single location where we can bring our best people together and give them the best tools in the world? Or in each market?

1.8.2 Loss of Control

In such a complex and challenging environment, it's easy for companies that develop, produce and support products to lose control over a product.

If a company loses control, the consequences can be serious. If it loses control during product development, the product may be late to market and exceed the targeted cost. The results of losing control during use of the product may be frustration and a lack of satisfaction for the customer, or much worse, injury and death. For the company, the results may be damage to the company's image and loss of customers concerned about product problems. They could also include loss of revenues to companies that bring products to market faster, and reduced profit due to costs of recalls and legal liabilities resulting from product use.

Some big numbers can be involved. For example, some figures were given in a January 2010 U.S. Government Accountability Office report. This showed that the cumulative cost growth in the Department of Defense's portfolio of 96 major defense acquisition programs was $296 billion and the average delay in delivering promised capabilities to the warfighter was 22 months.

An example of a product that was late to market is the Airbus A380. Delivery of the first A380 was originally planned for the last quarter of 2005. It was eventually delivered in the second half of 2007, 2 years late. The cost of late delivery was estimated to be $6 billion.

The problem with the A380 occurred well into the development project. However, problems with products can occur even earlier in their lives, for example during their specification. At the time of the commercial launch of the Airbus A350 in December 2004, it was expected to enter service in 2010. The initial specification was based on an extension to an existing aircraft. That implied rapid availability and a relatively low development cost. However, in view of limited interest from potential customers, an aircraft with a new design, the A350 XWB (Extra Wide Body), was proposed in 2006. Entry into service was announced for late 2014, 4 years later than previously expected. The first plane was delivered to Qatar Airways in December 2014.

Problems can also occur during product manufacture. For example, in 2006, computer makers such as Apple Computer, Dell, Hitachi, Lenovo and Toshiba announced the replacement of Sony-made lithium-ion batteries that could overheat in certain circumstances and pose a safety risk.

Problems can also occur during product use. On 25 July 2000, the crew of an Air France Concorde noticed a loss of power and a fire under the left wing soon after take-off from Paris. The aircraft went out of control and crashed onto a hotel. Two years earlier, on 2 September 1998, not long after take-off from New York, the flight crew of Swissair Flight 111, an MD-11, noticed an abnormal odour in the cockpit. Their attention was drawn to an area behind and above them, but whatever it was apparently then disappeared. They decided it was smoke and decided to land, unaware of a fire above the ceiling in the front area of the aircraft. The fire spread, degrading aircraft systems and the cockpit environment. The aircraft crashed into the Atlantic Ocean near Halifax, Nova Scotia.

Problems can also occur at product end-of-life. For example, the French Ministry of Defence had problems in 2005 and 2006 with Q790, previously known as the aircraft carrier Clemenceau. With hundreds of tons of asbestos on board, dismantling the hull for scrap was never going to be easy. A failed attempt to dismantle

Q790 in Turkey was followed by a decision to dismantle it in India. Q790 left Toulon in France at the end of 2005 to be broken up at Alang in India. After being refused entry to India, it was towed 10,000 miles back to France.

Counterfeiting can be another result of loss of control. Companies making products as different as software, clothing, DVDs and pharmaceuticals suffer from product counterfeiting and product pirating. A 2009 report from the Organisation for Economic Co-operation and Development indicated that international trade in counterfeit and pirated products could have been up to $250 billion in 2007.

Another type of product-related problem was highlighted in 2006 when it was announced that the FBI had thwarted an attempt to steal and sell Coca-Cola's trade secrets, apparently including information about a new product.

Problems aren't limited to high profile products and companies. Each month the website of the U.S. Consumer Product Safety Commission lists recalls of products such as drinking glasses that can break during use, cameras that can overheat, stools that can become unstable, lawn sprinklers that can crack, candle packaging that can ignite, and sweatshirt hood drawstrings that pose a strangulation hazard to children. Similarly, each month the U.S. Food and Drug Administration lists recalls, market withdrawals and safety alerts of products such as frozen strawberries, eye drops, blood glucose test strips, wet wipes and pharmaceutical drugs. And, each month, the Office of Defects Investigation of the National Highway Traffic Safety Administration lists Vehicle Recall Reports addressing parts such as automatic transmissions, fuel tanks, wiper motors, hoses, connectors, nuts and bolts.

1.8.3 Sources of Problems

Companies don't want to have problems with their products. These problems can cost a lot of money. If a problem does occur, a company will do everything it can to understand the source, and to prevent the problem happening again. In pre-emptive mode, companies try to identify and understand potential problems with a view to preventing them occurring. Time and time again it's found that the issues are related to the components that appear on the PLM Grid (Fig. 1.25).

Problem Area	*Issue(s)*
Products	Incorrectly, or unclearly, defined products
Data	Data out of control; data in silos; different definitions of data; incorrectly structured data
Processes	Processes not defined; unclear processes; conflicting processes
Applications	Islands of Automation; missing applications, ineffective application interfaces; unaligned applications leading to manual data re-entry and errors
Projects	Project status vague; unclear project objectives; too many projects
Equipment	Machines and software licences under-utilised or not used
People	Specific skills missing; lack of training
Organisation	Working methods not defined; differences between structures on different sites

Fig. 1.25 Some reasons for issues with products

1.8.4 Opportunities

PLM provides a way to overcome problems with the use and support of existing products, and with the development of new products. But PLM doesn't just have the potential to solve problems in the product lifecycle and in new product development. It also helps companies seize the many market opportunities for new products in the early twenty-first century. Existing technologies such as electronics, computing, telecommunications, robotics, biotechnology and the Web all offer scope for new products, as do newer technologies such as nanotechnology and genetics.

PLM enables companies to take advantage of the many product-related opportunities available at the beginning of the twenty-first century. Some of these opportunities are the result of new technologies such as the Internet of Things, Social Technology, Mobile Technology, Big Data, Analytics and the Cloud. Others are due to social and environmental changes, or to macroeconomic forces such as globalisation.

Globalisation has led to huge opportunities. Billions of people can now benefit from products to which they previously had no access. Companies can offer products to a global market. The resulting opportunities for sales and profits are enormous. So are the potential risks. For most companies it's only recently that such opportunities have been available. In the 1990s, although many companies were international, or multi-national, only a few were able to offer a product throughout the world. Others were limited, for one reason or another, to smaller markets. As a result of the changes, the potential market for most companies is no longer a few hundred million customers for the product in a local regional market, but over 7 billion customers worldwide. Which means that, for many companies, the potential market is already more than 20 times larger than before. And the market is expected to grow to 8 billion by 2025, and 9 billion by 2040.

The number of opportunities opening up in the twenty-first century seems boundless. Perhaps it was too risky to pursue them when the product development process was out of control, production runs in faraway countries had unexpected problems, and customers complained continually about product problems. But that was in days before PLM, when the paradigm was departmental. Now PLM's here, allowing companies to develop and support tiptop services and products across the lifecycle.

1.9 What Next?

The paradigm shift to the PLM Paradigm has important consequences. Many changes result. Many companies will never have faced such a broad-ranging change. They'll ask how they should respond to so much change over such a wide scope.

The rest of the book aims to help them reply to their questions.

Chapter 2 describes the typical environment of a company before PLM emerged. It will help readers understand the starting point for the PLM journey.

The following 5 chapters look at the 5 Pillars of PLM, the elements of PLM and the PLM Initiative that are key to success.

PLM is a new paradigm, a new way of looking at the world of products. It leads to new opportunities and new ways to organise resources to achieve benefits. In particular it leads to changes in the management of activities, product data and applications. Chapter 3 addresses *Business Processes in the PLM Environment*. Chapter 4 addresses *Product Data in the PLM Environment*. Chapter 5 addresses *Information Systems in the PLM Environment*.

The changes resulting from the paradigm shift are important. The effort to implement them is considerable. Most companies implement them through a formally-defined PLM Initiative. A PLM Initiative is likely to be challenging. Organisational Change Management (OCM) and Project Management are important components of a PLM Initiative. *Organisational Change Management in the PLM Environment* is addressed in Chap. 6. *Project Management in the PLM Environment* is addressed in Chap. 7.

Chapter 8 addresses the PLM Initiative.

Chapter 2
The PLM Environment

2.1 This Chapter

2.1.1 Objective

The objective of this chapter is to give a basic introduction to the product-related environment of a generic company before PLM emerged. This will help those in a company's PLM Initiative to understand some of the reasons why PLM emerged and why it's so important. In turn, this understanding will help them to participate more fully in the PLM Initiative. This chapter also aims to give students a basic understanding of the product-related environment of a company before the emergence of PLM.

2.1.2 Content

The first part of the chapter is an introduction to the product-related environment of a generic company before the emergence of PLM. It describes some of the issues, such as departmental organisation structures, serial workflow and piecemeal improvement that typified this environment. They resulted in slow and costly product development and support.

The second part of the chapter addresses product data, which was another problem area for companies before the emergence of PLM.

The third part of the chapter looks at the increasingly complex environment for products in the late twentieth and early twenty-first centuries. This environment became so competitive that companies couldn't afford to continue with slow and costly product development and support practices.

J. Stark, *Product Lifecycle Management*, Decision Engineering,
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The fourth part of the chapter presents some of the feedback from a review of a particular company's environment before it implemented PLM. It illustrates many of the issues addressed in the preceding parts of the chapter.

The fifth part of the chapter gives examples of some of the problems with products that occurred in other companies. PLM has the potential to help companies avoid such problems.

The sixth and final part looks at the opportunities opening up for companies in the twenty-first century. PLM enables companies to seize the many market opportunities for new products in the early twenty-first century.

2.1.2.1 Skills

This chapter will give students, who've been assigned this book for coursework, a basic understanding of a generic company's product-related environment before the emergence of PLM. They'll learn about some of the issues that occurred in this environment. They'll know how some people felt about the environment. They'll understand the product pains that occurred in this environment. They'll see the potential product gains and opportunities that are opening up in the early twenty-first century. They'll be able to explain, communicate and discuss about the environment before PLM.

2.1.3 Relevance

People joining a company's PLM Initiative may ask, "Why PLM, what's it for, why do we bother, why do we do this?" The answer lies partly in the past, in the way that companies worked before the emergence of PLM. But, why are things that happened before PLM relevant to a company's PLM Initiative?

A company only invests in an Initiative in order to improve performance. It invests in an Initiative so that it will operate better in the future than previously. When a PLM Initiative is proposed, the company's management will want to know what's going to improve. What bad things won't be repeated in the future? What great achievements will be attained in the future? The company knows how it wants to operate in the future, the "PLM way". Comparing this to the previous way will help show the changes that are needed and the size of the changes. And, in turn, these will show the structure and size of the PLM Initiative.

This chapter looks at the issues that occurred in the typical company environment before PLM. It will help people understand "Why PLM?" And, in turn, help them to participate more productively in a PLM Initiative.

2.1.3.1 It Depends Where You're Starting from

I remember reading, many years ago, a story about a tourist lost in the Irish countryside. At a crossroads, he sees a local farmer, and asks the best way to Dublin. After a few seconds, the farmer replies, "It depends where you're starting from". It's the same with PLM. The best way to get to the PLM environment described in Chap. 1 will depend on where you start from.

A company could ask the best way to get to PLM. The answer is, as the farmer said, "It depends where you're starting from".

But from where does the road to PLM start? What was the environment before PLM? Another question, how long will it take before all traces of the previous environment disappear? This is important because if, for example, the previous environment disappeared by 2005, it's not relevant for people planning for 2020. But if it's not going to disappear until 2030, it is relevant, but to what extent? And another question, what was the name of "Before PLM"?

2.1.3.2 Time for Complete Change

While I was looking for the answer to the question about "Before PLM", Brad Goldense wrote an article for 2PLM ezine called "The Embodiment of Open R&D Innovation Management Begins". Brad is the President of Goldense Group Inc. (GGI) and an expert on innovation, R&D and product development. The article was based on the results of GGI's "2014 Product Development Metrics Survey". In the article, Brad wrote

> Open Innovation [OI] is the ability of a corporation to invent and innovate using outside sources and resources, excluding the use of contracted personnel to supplement employee-equivalent responsibilities.
> The credit for coining the term, and beginning the body of knowledge related to Open Innovation, is generally given to Henry Chesbrough and the publication of his first book on Open Innovation in 2005. Certainly the underpinnings of this work began years before. Arguably, "the beginning" was the popularization of "benchmarking other companies" in the 1980s which changed historical practices of keeping private information within a company. Robert Camp's book on benchmarking in 1988 methodized corporate practices that had begun a few years earlier.
> Bodies of knowledge take four to six decades to flesh-out and mature.

My estimate of the time it would take for "Before PLM" to disappear was between one and two generations. I reasoned that, before someone could change a company to the PLM way, they would need to have worked at least 10 years in industry. And they'd need maybe 5–10 years to change the company. But, before that, they would have needed to be taught by a teacher or professor who had even more experience of PLM in industry. In 2014, only a handful of universities world-wide offered PLM courses. With that reasoning, it looked as if "Before PLM" would be with us for at least 30 or 40 years.

The time for the PLM Body of Knowledge to flesh-out and mature is related to the time it's going to take for "Before PLM" to disappear. I discussed this with Brad. He said his figure for the bodies of knowledge was based on his experience, and cited examples from other areas such as ERP, project management, nanotechnology, and robotics. Taking an unscientific approach, based on his estimate and mine, it looks as if it will take about 40 or 50 years for "Before PLM" to disappear.

2.1.3.3 Starting from, Ending in

From the date when PLM emerged, and the likely time for "Before PLM" to disappear, the date at which "Before PLM" will have totally disappeared can be calculated.

PLM emerged in 2001. It was needed in the new global environment for products. The previous 2 decades had seen many and frequent new ideas and changes, both in the World at large, in Manufacturing, and in the little world of PLM (Fig. 2.1).

2.1.3.4 The Name of "Before PLM"

In the second edition of this book, I referred to "Before PLM" as Pre-PLM. A reader pointed out that this could be confusing. Marie-Cécile Huo is the President

1982	W.E. Deming published "Out of the Crisis"
1983	Theodore Levitt wrote an article called 'Globalization of Markets'
1985	Michael Porter published "Competitive Advantage"
1986	Robert Cooper published "Winning at New Products"
1987	The Brundtland Commission reported on Sustainable Development
1987	Publication of ISO 9000
1989	Robert Camp published "Benchmarking: The Search for Industry Best Practices That Lead to Superior Performance"
1990	The world's first website and server went live at CERN
1990	James Womack published "The Machine That Changed the World"
1991	The Cold War ended
1992	Publication of "Engineering Information Management Systems: Beyond CAD/CAM to Concurrent Engineering Support"
1993	Publication of "Mass Customization: The New Frontier of Business Competition"
1993	Michael Hammer published "Reengineering the Corporation"
1996	John Kotter published "Leading Change"
1997	Clayton Christensen published "The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail"
2000	European Commission proposal C365E for the Restriction of Hazardous Substances (ROHS)
2001	Emergence of PLM
2004	Publication of the first edition of "Product Lifecycle Management: 21st Century Paradigm for Product Realisation"

Fig. 2.1 Twenty years of change leading up to the emergence of PLM in 2001

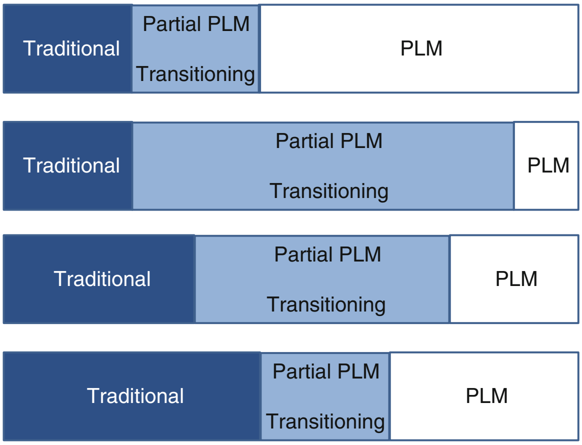

Fig. 2.2 Four different paths to the PLM environment

of KIMETIS, a Knowledge Management and PLM consultancy. She pointed out that, although PLM emerged in 2001, companies didn't immediately stop operating the previous way and switch overnight to the "PLM way". Instead they went through a transitional phase on the way to PLM, doing Partial PLM (Fig. 2.2). This phase started at different times in different companies. And during this phase, which varied in length from one company to another, they were on the way to PLM. During this transitional phase, some people in the company would say that they were doing PLM. Other people in the company wouldn't even have heard about PLM. PLM was very much in the eye of the beholder.

Some companies start the transition to PLM early, some start it later. Some companies transition quickly, some take longer.

2.1.3.5 The End of "Before PLM"

On the basis that PLM emerged in 2001, and it will take about 40 and 50 years for "Before PLM" to disappear, the previous environment won't disappear until at least 2040. So, an understanding of that environment is relevant to companies wanting to achieve PLM before 2030.

2.2 Issues in the Traditional Environment

Among the main issues in the traditional environment were serial workflow, departmental organisational structures and piecemeal improvements.

2.2.1 Serial Workflow

In the traditional environment, workflow was serial. A product might start life in the marketing department, and then go through conceptual design, engineering design and analysis, testing, detailed design, manufacturing engineering, process planning, tooling, NC programming, production planning, purchasing, machining, assembly, testing, packaging, technical publishing and installation. In the middle of life it would be used and maintained. Then, at the end-of-life, came activities such as retirement and disposal.

In the traditional environment, it could take a long time for a new product to get to market as it went through the Marketing, Engineering, Manufacturing, Sales, Support chain. First of all, Marketing came up with a new idea. This didn't take long because the people in Marketing were very bright and well-educated. They wanted to get the product on the market before the competitors. That way, it would make a lot of money for the company. However, when they talked to Engineering, they were told that Engineering was already over-burdened with far too many projects. Engineering couldn't start work on yet another new product!

When Engineering did have some free time, it realised it didn't quite understand Marketing's idea. Engineering asked for more details, but the Marketing people were away at an international meeting and wouldn't be back for 2 weeks. When they did come back, the Engineering Manager was away. The Engineering project leader who had been assigned to the idea discussed it with the people in Marketing. A week later he went back to Marketing with some suggested changes. Marketing had also thought of some changes, and the engineers went away to see if they could develop something from the new ideas. When they had defined everything down to the last detail, they passed it over to Manufacturing. Manufacturing replied that it couldn't produce the product the way it had been designed, and asked Engineering to change it. The changes would have such an effect that Engineering decided to check with Marketing. When they did, they found that in the meantime, Marketing had realised that some additional functions were needed. And Marketing had come up with some new ideas for the packaging. The engineers went away to see if they could develop the new ideas. This iterative process continued until the departments eventually agreed about the product and its release to the market. A prototype was installed for a customer. The installation engineer claimed that installation time was too long, and proposed some changes. The customer told Marketing the product was too expensive, and anyway, didn't behave the way it should.

The result of this approach was that the product got to market late, was too expensive, and didn't meet customer requirements.

It took so long because the departments worked in series. Marketing took 2 weeks to do its job, then Engineering took 7 weeks, then back to Marketing for 1 week. Then on to Engineering for 3 weeks, then on to Manufacturing for 2 weeks, then back to Engineering for 2 weeks. Then back to Marketing for 1 week, then on to Engineering for 1 week, then on to Manufacturing for 3 weeks. Then back to

Fig. 2.3 To and fro for 25 weeks

Marketing	*Engineering*	*Manufacturing*
2 weeks		
	7 weeks	
1 week		
	3 weeks	
		2 weeks
	2 weeks	
1 week		
	1 week	
		3 weeks
	1 week	
		2 weeks

Engineering for 1 week, then on to Manufacturing for 2 weeks. 2 + 7 + 1 + 3 + 2 + 2 + 1 + 1 + 3 + 1 + 2 = 25 weeks (Fig. 2.3).

Then Service took a week, and the customer took 4 weeks to do a one-day test. Then, Service took another week to write its report. Engineering had to make a change which took another 2 weeks. Marketing took a week to review the change. The change took 3 weeks to go through Manufacturing. 1 + 4 + 1 + 2 + 1 + 3 = 12 weeks (Fig. 2.4).

5 weeks in Marketing, 16 in Engineering, 10 in Manufacturing and 2 in Service, and the whole thing was stretched out over 37 weeks.

Working in series increased costs. During the 11 weeks out of the first 25 weeks that the product was in Marketing and Manufacturing, Engineering wasn't working on it. Assume that the engineers weren't working on another product. What happened to their wage costs during those 11 weeks? They were added to the product cost. The product cost (and price) was increased to include 11 weeks of non-value adding Engineering time. Time is money. The longer a product stays in the product development phase, the more costs it picks up.

2.2.2 Departmental Organisations

Although the above approach may appear nonsensical, there are good reasons for organising the company in departments (Fig. 2.5).

Marketing	*Engineering*	*Manufacturing*	*Service*	*Customer*
			1 week	
				4 weeks
			1 week	
	2 weeks			
1 week				
		3 weeks		

Fig. 2.4 To and fro for another 12 weeks

get people to focus on a few activities	propose people a clear career path
encourage people to excel in a few activities	have clear responsibilities
train people about departmental working methods	use the most appropriate tools for the job
give individuals the time to learn specific skills	let people get to know their colleagues well

Fig. 2.5 Some advantages of a departmental organisation

However, although there are many good reasons for organising the company in departments, there are also many disadvantages. Serial product workflow through the departments was just one of the problems (Fig. 2.6).

In the traditional environment, product development and support were carried out in a conflictual atmosphere with individual departments competing against each other and reacting to problems. Changes, scrap, delays, work-arounds, waste, and rework were seen as normal behaviour. Management focused on supervising individuals. Fire-fighting was necessary and rewarded. Internal bureaucracy, back-stabbing, turf battles, and cosmetic changes to the organisation chart added problems and unnecessary operations on an on-going basis. The only thing that seemed to keep such organisations together was their fear of the common enemy, the customers.

In the traditional environment, people in different functions weren't encouraged to communicate freely. Often they didn't agree about what they were doing. At one extreme, forward-thinking engineers developed products that customers might not want. At the other extreme, salespeople sold products that Engineering couldn't develop. And Marketing proposed products that it thought customers wanted, but they didn't actually buy. Service engineers didn't get the information to enable them to track product revisions. As a result, they couldn't control the timing or cost of repairs and upgrades. Management couldn't assess the business impact of a change to a product because no-one knew what was really going on. In some companies, management got so frustrated that it set up a parallel organisation outside the company to do the job better. And from there, it was only one step to outsourcing all product development and support.

Marketing's estimate of the cost of a product development project might differ from R&D's, and from that made in F&A. After talking to F&A, Marketing might have had discussions with R&D and changed its customer segments and estimates. Marketing might propose products that R&D couldn't develop. Someone in R&D might have said that it would be good to develop them, but not meant to imply that they could be developed. Design engineers might send manufacturing engineers designs that couldn't be produced. The design went back for rework. Engineering changes costing thousands of dollars resulted.

multi-level hierarchies	use of specialist jargon
departmental disputes, empires and emperors	uncoordinated performance targets
poor communication	products not meeting customer requirements
serial workflow	walls built to demarcate departmental frontiers

Fig. 2.6 Some problems of the departmental organisation

The Engineering/Marketing, Engineering/Finance and Engineering/Field frontiers were also sources of problems. Sales people offered customised versions without knowing if it would be possible to produce them profitably. Design engineers were unable to get the cost information they wanted from the Finance function. Finance professionals were unable to get the information they needed from the Engineering function. Design engineers didn't receive field reports about product performance in the field, and designed existing problems into new products. Maintenance requirements weren't taken into account during conceptual design.

One reason the product was too expensive was that so much time was used up in the development process. And, with so many false starts, the real customer requirements could get lost. Another reason that the product might not meet customer requirements was that too many decisions were taken inside the departments without any reference to the customer. Errors and misunderstandings crept in as the product description was sent to and fro between departments. Each department used the vocabulary best suited to its activities. It had difficulty communicating with the other departments which used their own vocabularies. Errors and other confusion crept in through misunderstanding of each other's jargon.

And, if an error got into the design, often it wasn't clear who was responsible for getting it out. Marketing might look at a problem and decide it was a problem for Engineering to resolve. Engineering might look at the problem and decide it was a problem for Marketing to resolve. Manufacturing might look at the problem and decide, like Marketing, that it was a problem for Engineering to resolve. Support might look at the problem, and see the solution, but not tell anyone, on the assumption that someone else had seen it as well. Everyone spent time looking at the problem, but no-one felt directly responsible, so no-one solved it.

2.2.3 Piecemeal Improvements

The traditional environment was based on the premise of each department being excellent at a limited number of activities.

If they're assumed to be excellent, can they improve? Let's assume they can but, if they are the experts in their specific area, such as Engineering, it seems logical that nobody else in the organisation can help them. Can you imagine experts in Engineering asking people from Marketing for advice about Engineering activities?

So, if performance improvements are really needed in a departmental organisation they are, naturally, implemented on a departmental basis. Each department works on its own improvement projects. Each department is responsible for its own performance, so does what it can to improve itself. Each department does its "piecemeal improvement". This has three main characteristics. It mustn't affect the other departments, because that's not the way departmental organisations behave. It must involve IS applications because everyone knows they improve everything. It must be a Mega-project, a huge project that by its magnitude alone will attract management attention and demonstrate the quality of the department.

quality problems	not enough people to do the work
information silos	technical problems with new products
communication silos	equipment under-utilised or over-booked
Islands of Automation	using obsolete components in a new design
redundant part numbers	increasing rework and engineering changes
cycle times lengthening	difficulties to take back retired products
problems with legacy data	product development and support projects coming in late
lack of up-front planning	service costs increasing, while performance deteriorates
poor scheduling of projects	delays as new technologies and features become available
information security problems	optimising product layout, but lengthening delivery cycles
poor supply chain co-ordination	products meeting specifications, not customer requirements
product development costs rising	optimising product performance, fragmenting the supply chain

Fig. 2.7 Many product-related problems

In the Marketing Department, for example, Big Data and Social Media initiatives are launched. Bigger databases and more powerful servers are brought into understand customer needs better, and to provide better segmentation of customer profiles. More Customer Focus Groups are created in faraway locations. Sales Associates are equipped with the latest mobile devices to enable them to stay up-to-the-minute with customers' unique needs, trends, recaps of previous sales meetings, latest prices and discounts.

The Support Department puts its database of product information on the Cloud to provide service engineers with access wherever they are. In the Engineering Department, old generation CAD applications are replaced by the latest technology. 3D printers are installed to produce prototypes rapidly. EDM applications are upgraded to PDM applications. The Manufacturing Department upgrades the controllers on its existing NC machines, and buys powerful new machine tools. More modules and interfaces are bought for the ERP application. It's moved off hardware with an old architecture to one with a new architecture.

The result of these projects is generally invisible. The company continues to produce products that are late to market, cost too much and are of poor quality. Even if Engineering buys the most modern CAD technology, it's not going to make much difference. Designing products that customers don't want with a modern CAD application isn't any better than designing products that customers don't want with an old CAD application. More unwanted designs will be produced, creating even more pressure on Manufacturing, and distorting the production plans. And when the products do get into use, there are problems, and they have to be recalled.

After all the investment in departmental improvement initiatives, companies still suffer from many product-related problems (Fig. 2.7).

2.3 Product Data Issues

Another issue that companies had to face at the end of the twenty-first century was the rapidly growing volume of product data.

2.3.1 A Lot of Product Data

Companies have a lot of data describing their products. All but the smallest companies have thousands, or even millions, of drawings and other documents describing their products. One company calculated that it needed 250,000 pages of paper to describe a new product, and that, on average, each of these was reproduced 30 times. Printed on paper, the technical documentation for a helicopter weighs more than the helicopter. That for a submarine exceeds 100,000 drawings, of 10 different sizes, weighing more than 5 tons. Some of the data is huge. A single 3D CAD part model may take up several gigabytes. Some companies have hundreds of thousands, or millions, of such models. As an example of the volumes of data involved, in 2001, a major outsourcing contract for technical document services was agreed by Rolls-Royce plc, a global company providing power for land, sea and air. At that time, Rolls-Royce plc annually produced 96 million copies, 20 million printed drawings, microfilms and geometric designs, and archived over 30 million drawings.

In the traditional environment, each department was responsible for its performance, so wanted to manage its own data. But a lot of this data was needed by people in other departments. The easiest way to give them all access was to take copies for everybody. However, once several copies had been made and distributed, it was difficult to keep them synchronised. When a change was needed, perhaps some copies weren't changed, some users weren't informed, and some downstream functions weren't alerted. Errors resulted.

In the traditional environment, to find specific information, people had to search through a lot of paper and electronic files. This wasted valuable time. Studies showed that design engineers spent up to 80 % of their time on administrative and information retrieval activities. Sometimes they just made a simple request for information that "belonged" to another department, and had to wait several days to get it.

In the traditional environment, there were many opportunities for errors to creep into product data. Data entry was often poorly controlled. It was easy to type the wrong character or copy the wrong file. Data got lost and couldn't be retrieved. Then it was re-created and errors were introduced. Due to gaps between incompatible applications in different departments, data was transferred manually between the applications. Errors occurred. Some were spotted and corrected. Others slipped through, and weren't discovered until they caused product problems.

2.3.2 Poor Change Management

Companies were aware of the importance of product data. They knew that any errors in the data could have disastrous effects on the product.

To avoid problems they carried out multiple checks on information before it was officially approved and released. And they had Engineering Change Management (ECM) processes and systems to control any changes that might be required later. However, in the traditional environment, these systems were often bureaucratic, paper-intensive, complex and slow. A central engineering services group might have had the responsibility, but not the tools, to push the changes through as quickly as possible. Many departments could be involved (one manufacturer found that, depending on the change, up to 16 departments were involved). As a result, it could take several months, and fifty or more different documents, to get a proposed change approved and incorporated into the product design. Even when a change had been agreed and announced, many months could go by before the corresponding documentation got to the field. Though the change process took months, the actual processing time might only have been minutes or hours. The rest of the time was wasted.

When many changes, and changes to changes, were required, they were difficult to co-ordinate. As a result, some unwanted changes could be introduced. And maybe some required changes didn't take place. Unreleased versions of data were acquired by Manufacturing, Sales and Support, causing confusion and waste.

As the data management and change process appeared to be an inefficient and time-consuming overhead, some people avoided it. Minor modifications were made to products and drawings without informing anyone. Components were substituted in end products without corresponding changes being made to test routines. People failed to maintain the trace of the exact ingredients in ever-smaller batches of products. Nobody noticed until something went wrong or another change had to be made.

Eventually, configuration control broke down. Configuration documentation no longer corresponded to the actual product. Increased scrap, rework and stock resulted. Incomplete products were assembled and delivered. Customers complained. Field problems were difficult to resolve. Then, unnecessary effort was needed to find the source of the problem. And more effort was wasted on fixing it.

2.3.3 Data not Linked to Management Tools

In the traditional environment, project management tools weren't linked to the product data being created and used in product development and support projects. As a result, the tool didn't automatically know the status of the data. Overlap in data and work resulted, wasting time and money. Any attempt to save time, by running the various activities of a project in parallel, led to chaos. To keep everything under control, the activities were run in serial, lengthening project cycles. Rules and procedures could be ignored because there was no way to enforce them. Project managers found it difficult to keep up-to-date with the exact progress of work. They were unable to address slippage and other problems as soon as these occurred.

2.4 A Complex, Changing Environment

The environment in which products are developed, produced, used and supported is complex, stressful, competitive and changing. Complex and changing situations typically have two characteristics, danger and opportunity. Companies that understand the changes can respond to them and avoid the dangers. They can also adapt and benefit from the opportunities.

2.4.1 Change

One of the reasons that Product Lifecycle Management emerged in the early years of the twenty-first century is that the environment in which products were managed became increasingly complex. And to make matters worse, the environment underwent frequent changes.

A lot of companies would be happy if there were never any changes in the product environment. They could then organise themselves, as well as possible, to provide customers, as efficiently as possible, the same product, day after day, year after year. They wouldn't need new products. Over time, they would probably be able to eliminate most of the problems with existing products. They could plan exactly how many products to produce and sell. Everyone would be happy. There would be no need for anything to change. As the global population increased, market sizes would increase. As companies went down the experience curve, they would reduce costs and increase profits.

However, the situation in the twenty-first century isn't anything like that. The world environment for products started to change significantly in about 1965. And from 1980 onwards, the environment changed radically.

The changes had a huge effect on companies developing and supporting products. In the early 1990s, one company that I worked with annually renewed less than 10 % of its products. By 2009, it annually renewed 75 % of its products.

Another company that I worked with had operations in 6 countries in 2000. In 2010 it had operations in 26 countries. Usually it set up new operations in these countries. However, sometimes it acquired other companies. Each acquired company had different systems and procedures. Initially, it was thought that they could continue to work with them. However, this caused so many problems that it was decided that, to get everybody working together effectively, the systems and procedures had to be aligned worldwide (i.e. in 26 countries).

2.4.2 Interconnections

Not only are companies in a complex environment that is affected by many different changes, but the changes are often intertwined. As a result, the product environment is becoming increasingly complex with many interwoven components and numerous interdependencies being affected by many overlapping changes. The resulting environment is so complex that it's often difficult to see what the changes are, and what is really driving them, or to understand how they will affect a particular company and a particular product.

2.4.2.1 Macroeconomic Changes

Some of the changes are primarily macroeconomic and geopolitical (Fig. 2.8). For example, globalisation is a change that has affected many companies and products. It can have many effects on a company, even a small one. One positive effect is that the company can sell its products and services worldwide. It can find many new customers and increase sales. Another effect of globalisation is that even small and medium-sized companies are faced with competitors all over the world. And they may find that these competitors bring out similar products, but with better cost-performance than their own models. As a result, they have to be more innovative, develop better products, develop them faster and develop them at lower cost.

Geopolitical changes, for example those resulting from the end of the Soviet Union, affect the product environment. The end of the Cold War led to many countries taking different roles in the global economy. In the 1980s, most of Poland's exports went to Warsaw Pact countries. In 2009, Poland's main trading partner was Germany. In the years leading up to President Nixon's 1973 visit to China, there was little trade between China and the US. By 2008, the US was China's main trading partner.

2.4.2.2 Environmental Changes

Other changes are primarily environmental and social (Fig. 2.9). For example, in response to the rising recognition of the potential dangers of products and

deregulation	rise of service industries
globalisation	fluctuating commodity prices
ageing population	influence of financial markets
geopolitical developments	shareholder demands to increase value
fluctuating exchange rates	multi-cultural, multi-lingual environments

Fig. 2.8 Some macroeconomic challenges facing product companies

sustainable development	accidents affecting the environment
recycling directives	product traceability
regulatory requirements	global warming

Fig. 2.9 Some environmental challenges facing product companies

production to mankind and the planet, the focus on the product lifecycle has increased steadily. Politicians and ecologists influence business behaviour, forcing companies to think about environmental issues, waste products and recycling. Issues concerning the end of a product's life are increasingly taken into account during the design stage.

Companies are faced with an increasing number of regulatory requirements. These are aimed at protecting customers and others. Regulators need proof that their requirements have been met. The proof comes in the form of documents. They include documents about product characteristics, documents about analysis of the product, and documents concerning tests of the product. Other documents, for example, process descriptions, describe the way that work is carried out. Regulations are often voluminous and liable to frequent changes. Just managing the regulations, and relating them to different products and services in different countries, is a time-consuming task for a company.

Regulations lead to requirements for analysis, auditing and reporting of everything from food and beverages to cosmetics and chemicals. Regulations are often introduced with the intention of doing good for mankind. The European Union (EU), for example, introduced the Restriction of Hazardous Substances (RoHS) directive to address use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ether. The EU's Waste Electrical and Electronic Equipment (WEEE) directive was aimed at managing waste electrical and electronic equipment. The EU's End of Life Vehicle directive is aimed at getting manufacturers to dispose of vehicles in an environmentally sensitive way.

There are increasing demands for product traceability from regulators and consumers to provide and assure safety. Product traceability is important in industries ranging from food and pharmaceutical to automotive and offshore. If an airbag fails, a car manufacturer wants to find all the others from the same batch as soon as possible. If an oil rig collapses, any steel parts at fault need to be identified so that similar problems can be avoided on other rigs. Organisations that can successfully track products and parts are at an advantage compared to competitors that can't. Recalls of millions of parts, or millions of products, are very expensive, and may cost millions, or even billions, of dollars.

2.4.2.3 Corporate Challenges

Some of the changes in the product environment are due to changes in the way that companies operate (Fig. 2.10). For example, the changing business environment provides opportunities for new business models to be developed. This can make life difficult for companies operating with more traditional models.

Some companies no longer manufacture their products, but outsource all production so that they can concentrate on product marketing, development and sales.

offshoring	large volumes of data
outsourcing	corporate restructuring
partnerships	product lifecycle focus
change management	changing business models
knowledge management	multiple versions of processes
multi-site activities	retirement of knowledge workers
process reengineering	increased complexity of business
improved supply chain	high cost of training new employees

Fig. 2.10 Some corporate challenges facing product companies

Some companies look to the producer of a product to operate it as well. Some companies offer their products for lease rather than for purchase. For example, aircraft, trains and cars can be leased. Some software is offered on a pay-for-use basis over the Web rather than for purchase. Some companies offer guaranteed product performance. They may guarantee that their products will run for a certain number of hours per month. Or that a certain percentage of products will still be in service after 10 years. Some companies cut out the traditional sales force by only selling over the Web. Others allow customers to set the price they will pay for a product at an online auction.

Other changes occurred in the late twentieth century and early twenty-first century as companies adopted and adapted to management theories such as “Lean”. This is a management theory focused on creating value for the customer, eliminating any wasteful activities that don’t create such value (Fig. 2.11).

Low-cost product and service providers aim to cut out waste and non-essential functions. They may get customers to carry out some activities themselves, or to pay for them separately. Fast-food eateries eat into the restaurant market by offering reduced choice, standard menus and no waiter service. Other companies compete by providing ready-to-eat food and drink products that are sold in shops for customers to eat on the street, or next to you on public transport. Some pharmaceutical companies focus on providing low-cost generics that have the same effect as existing high-cost brand-name drugs.

Another change that has occurred in recent years is the increased focus on Intellectual Property. Whether in the form of company proprietary information, trade secrets, enabled publications, copyright, trademarks, provisional patents or

Fig. 2.11 Waste to be eliminated

transportation
inventory
motion
waiting
overproduction
non-value-adding processing
defects

patents, this is increasingly recognised as a source of company value. Ownership gives rights over property, whether it's a tangible property or intellectual property.

Product data/information (product know-how) is one of the most valuable resources in a company. In the 1980s, it was usually on paper, difficult to access, difficult to transport. By the year 2010, most product data was electronic, increasingly easy to find and communicate anywhere. To protect it, in the face of increasing global competition and the potential risks from terrorism and economic espionage, companies needed an "Intellectual Property Vault".

2.4.2.4 Technological Changes

Some of the changes that occurred in the product environment are due to new technologies and new products (Fig. 2.12). For example, many companies now develop mechatronic products. These are products that contain a mixture of mechanical, electrical, electronic and software modules. Companies often develop mechanical, electrical and electronic components in a similar way, with similar processes and applications. However, the processes and applications used for software development are usually very different. Companies have to adapt to work effectively with mechatronic products.

In many industries, onboard electronics and embedded software are major areas for innovation. For example, in 2010, some cars had about a hundred onboard electronic control units, with tens of millions of lines of software. These devices provide a wide range of functions, for example, to help drivers find the right direction, park, steer and avoid other cars. The value of the electronic components in a car may represent more than 25 % of the total value.

Internet and the World Wide Web have enabled the development of many communities. These groups of people have, and share, knowledge and experience of a particular subject. Sometimes linking thousands of people, they have collective knowledge and experience greater than that of most companies. Such reservoirs of knowledge, experience and ideas didn't exist in the twentieth century. They offer companies many opportunities. Companies can work with communities to find ideas for new products and processes, and to identify ways to improve existing products and processes.

IS evolution and complexity	World Wide Web and Internet
toolbox Information Systems	cloud computing
Open Source software	nanotechnology
mobile communications	mechatronics

Fig. 2.12 Some technological challenges facing product companies

increasing product functionality	parallel world of software development
increasing product/solution/service complexity	working effectively with partners
global products	products with very long lives
customisation	new customer requirements
large volumes of data	fast-changing products
mechatronics	increased competition

Fig. 2.13 Some product-related challenges facing product companies

2.4.2.5 Product-Related Changes

By the end of the twentieth century, the environment for developing and supporting products was changing. Companies were faced with all sorts of issues with products (Fig. 2.13). Competitors around the world kept on innovating. More and more new products were launched. The functionality of products kept on increasing, complicating their development and support.

Product development and support got more and more challenging. Products became increasingly complex with more and more parts and functions. Although products got more complex, they still needed to be easy to operate, otherwise customers wouldn't buy them. For example, cars contained more and more electronics, but still needed to be easy to use. Phones had much more functionality, but still needed to be easy to use. Since many people were unable even to operate the controller of their television, companies had to make products that were easy to use, even though they were actually more complex.

Many companies started to offer complete solutions, rather than individual products. A solution is made up of several products, and the interfaces between them. Solutions added a new layer of challenges. They were more complex to develop and support than single products. Some products and solutions got so complex that no individual could understand them.

Further complicating product development and support, the lifetimes of many products (for example, telephones and computers) decreased significantly. Many products had lifetimes of less than a year (Fig. 2.14). The lifetime of some products was so short that the development of a future generation had to start before the development of the previous generation had been finished. In fast-evolving technological environments, products become obsolete sooner. The reduced time between product launch and product retirement erodes sales revenues. Since this

Fig. 2.14 Typical product lifetimes (2003)

Product Lifetime	*Percentage of products with lifetime in this range*
less than 1 year	10%
less than 2 years	20%
less than 5 years	50%
less than 10 years	75%

phenomenon depends on factors beyond a company's control, the only way it can lengthen a product's life is to get it to market earlier.

On the other hand though, but also adding more complexity and complication, lifetimes for some other products approached 100 years. The B-52, for example, first flew in 1952. Its original lifetime was extended until it was expected to fly beyond the year 2040. The support of products with very long lifetimes, such as aircraft, power stations and telephone exchanges, is complicated by the many changes in the product development and support environment that occur during their lifetimes. The media on which product data was originally stored may no longer exist. The IS applications that created this data evolve through many versions. Application vendors mature and disappear. Even the company that made a product may disappear during the product's lifetime. For example, Concorde was developed by the British Aircraft Corporation and Aerospatiale but, by 2000 when a Concorde crashed in Paris, neither of these companies existed. However, customers and regulations may require companies to produce documentation about products they, or predecessor companies, developed 50 or more years ago.

Even though product development and support was becoming more complex, customer expectations were rising. With so many manufacturers around the world proposing products, why should a customer settle for a second-rate product? Customer demands implied better products and services, a wider product range, customisation and market niches. But there was also increasing consumer resistance to price increases. At the same time, there were technology issues to be faced, including the effect of the increasing amount of electronics and software in products, the possibilities offered by widespread communication networks, and the rapidly decreasing cost of computer power.

Business was becoming more complex. There was more and more uncertainty in developing new products. Uncertainty came from a global marketplace, a wider range of customers, shorter product life cycles and more competition. This meant greater uncertainty about the life of products and investment decisions associated with them. There was growing competitive and legislative pressure. Legislation such as that concerned with product liability, deregulation, privatisation, health, safety and the environment put additional strains on business.

It was difficult for a company to know what the effects of all these changes would be. That made it difficult to develop long-term plans. The price of failure was high. Why take the risk? Why risk billions of dollars developing a new commercial aeroplane when the potential customers may decide, at some unknown date in the future, not to take up their options, or may not, by that time, even exist?

2.4.3 Changes Driving PLM

Among the many changes that companies faced, some can be seen as global economy drivers pushing PLM (Fig. 2.15). Executives would look at them and say "we have to do PLM because the world has changed".

outsourcing	corporate restructuring
globalisation	sustainable development
demanding customers	evolution of information systems
product traceability	complexity of information systems
recycling directives	shareholder demands to increase value
increased competition	mass customisation and personalisation
multi-site activities	multi-cultural, multi-lingual environments
mobile communications	increasing product/solution/service complexity

Fig. 2.15 Global economy drivers pushing PLM

Fig. 2.16 Technologies pulling PLM

powerful DBMS	GPS
telecommunications	RFID
World Wide Web	ambient computing
computer power	GRID computing
mobile telephony	Internet

Other changes can be seen as technological advances pulling PLM (Fig. 2.16). Executives would look at them and say "we can do PLM because the world has changed".

2.4.4 Result

As a result of the changes, many companies felt squeezed between technological changes on one side and economic forces on the other side (Fig. 2.17).

Among the many changes, some create opportunities, some create problems, some lead to the need to change, some are the source of more changes. The resulting changes can drive other changes. Unexpected events resulting from changes can be a source of further change. All these changes snowball, making it difficult for a company to know how to respond.

In addition, changes have associated risks. Changes in one area may lead to enhanced risks in another area. If the risks were only related to one component or change in the environment, it might be easy to manage them. Unfortunately though, they are often related to many changes, making their management difficult.

It's sometimes difficult to clarify if a particular change is a driver of change, or an effect of change, or both. Often, the changes may be seen either as reasons for change or as effects of change. For example, increased competition could be seen as a reason for change, or as an effect. For a particular company, increased competition may be seen as an effect of globalisation. However, for that company, increased competition may also be seen as a reason for changing the way it operates.

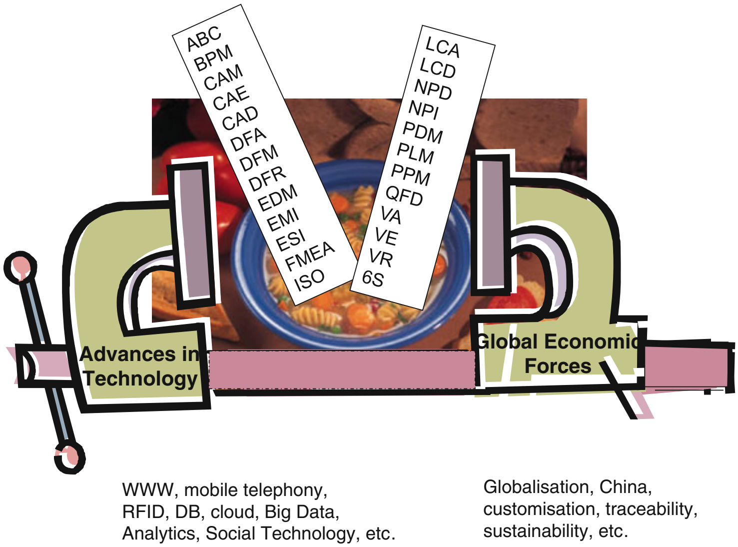

Fig. 2.17 Squeezed between technological changes and economic forces

2.5 Example from “Before PLM”

As the following example shows, the complexity, the changes, and the continuing need to compete can lead companies into difficult situations. The example presents some of the feedback from a review of a particular company’s environment before it implemented PLM.

Global Auto Components (GAC) provides an example of the issues found in the environment before PLM. GAC is a Tier 2 manufacturer of assemblies and components for the automotive sector. With world-wide sales of about $3 billion, the company operates in about 50 countries. The workforce numbers about 10,000.

2.5.1 Introduction

In GAC, product development timelines were too long. It had even missed the window of opportunity on new products because it couldn’t get into the market before the competition.

Forward planning was difficult with uncertainties in sales estimates, competitors in low-cost countries producing copies, and cost pressures and changes coming from OEMs. It was expected that, in the future, there would be a need for a greater proportion of software and electronics in products. But these were areas in which

GAC had little experience. Increasingly, there was overlap between projects, and customers were mixing components together more and more. A need was seen for a more systems engineering approach to projects in future. This was also an area in which GAC had little experience.

Top executives were highly stressed. Each launched many improvement initiatives in their own parts of the organisation. They blamed each other's functional areas when things went wrong. Marketing called for more Customer Focus. R&D managers included new technologies in products. Business planners examined opportunities for further global expansion. Acquisition, restructuring and cost-reduction projects were running in different countries and for different product families.

In spite of the many improvement initiatives, problems with products continued and showed no sign of abating. As a result, the CEO decided to call in consultants to conduct a company-wide product development audit, to identify problem areas, strengths and weaknesses, and to develop resulting action plans.

To help understand what was happening, we conducted interviews with a range of people from each function, and the following selection of comments was included (anonymously) in the report to give the CEO and other readers a feeling for the perceived situation. The following figures (Figs. 2.18, 2.19, 2.20, 2.21, 2.22 and 2.23) show the feedback from different groups of people in the company.

2.5.2 *Quantitative Feedback*

The "Voice of the Employee" comments gave top executives a qualitative feeling for the issues the company was facing. This was reinforced by quantitative information which was presented on two slides (Fig. 2.24).

"We don't have a clear overview of where we are with our product development projects."

"R&D doesn't understand that we have to do business, not just play at making new toys."

"We agree a budget to develop a product, R&D develops it, then they ask for another budget so they can redevelop it and remove their mistakes."

"Culturally, this company was historically focused on individual products, not on the overall portfolio of products."

"We need to get Sales, R&D and the plants to plan together for new products."

"We have sales figures for our 65,000 components. I want to see how those sales figures will be affected by new products we're bringing to market. We've spent millions on new products that bring less revenue than the products they replace. We destroy our own value."

"The Board needs a clear overview of project status at every monthly meeting."

"I'm concerned about our new products that have a high software content. They're about a year late to market. Early versions are riddled with glitches."

Fig. 2.18 Feedback from interviews with top management

“With a huge global market, we have countless opportunities, and many ideas for innovative new products and services. But R&D is unable to deliver.”

“R&D reinvents everything. We need a VP of R&D who enforces standardisation and reuse of existing components.”

“Customers are asking us to work with their processes, applications and documents. That’s great. It gives us insight into their plans. That gives us a head start. The problem is that our processes and systems are not set up to take advantage of this information.”

“The Production VP tries to block new product projects because bringing in a new product reduces plant productivity.”

Fig. 2.19 Feedback from interviews with marketing

“They keep changing the priorities of our projects, so as soon as we start making progress with one project, we have to switch to another one they say is more important. A few weeks later they say another project is even more important, so then we have to switch to that one. It’s inefficient use of resources and frustrating.”

“I used to work for one of our competitors. A friend there told me they now have all their product development project information on the Web so everyone knows what’s going on. They have a standard cockpit chart for each project.”

“I don’t have a tool to manage my projects effectively.”

“There are no guidelines for Risk Management.”

Fig. 2.20 Feedback from interviews with product development project managers

“We haven’t grown our resources to meet the growth in company size. Since I’ve been here, the company has grown 500% but the product portfolio group is still the same size. If we had more people, we could get more data about our products in the field. We could use it to help plan projects for replacement parts.”

“Data checking takes about 70% of my time.”

“In our planning process we don’t have a way to value the potential reuse of a new component in future products.”

“Different project managers provide different data about their projects. That makes it difficult to compare projects and to roll up data.”

“Our current ERP system doesn’t take account of the manufacturing location. When it was built we only had one location, now we have five, and the costs for each are different.”

“Often a project for a new product implies removal of an old product from the market, but there isn’t a process to do this. So the old product stays on the market. Some customers continue to buy the old product, which reduces sales of the new product.”

“We don’t do audits of projects after they finish. It would be good to look back at a project five years after it finishes to see what we can learn from how it ran, and how the product has performed in the market.”

“With all the cost pressures these days we don’t have people looking to see what we will need in 10 or 15 years.”

“Ten percent of our products bring 90% of our revenues. I’d like to find a way to avoid projects that lead to products that don’t make money.”

“The data we have about products for OEMs is about 10 times better than products for the aftermarket. That makes it difficult to apply the same value analysis techniques.”

“There are too many projects in the company, many are never completely finished.”

Fig. 2.21 Feedback from interviews with corporate planning

“Each year, a new corporate plan is announced and the actions in it usually impact our R&D projects in several ways. Both intended and unintended. I guess someone up there is doing their best for the company, but they don’t seem to realise what the real situation is down here.”

“Marketing people don’t realise how much effort is required even for a minor upgrade for their favourite customer. And they don’t understand all the work they make when they keep on asking for changes after we’ve started the projects. Why don’t they do their homework before starting the project? And besides, we have almost no time to do real work. Anyone above a trainee engineer spends most of their time in meetings and producing paper. I waste hours each week on tasks that are duplicate work and rework.”

“We have trouble working with the guys in Europe on global projects. They have a different project management system and work with different milestones. And they think differently.”

“Project Managers don’t define in enough detail what is expected of us in a particular project. Different managers use different methods and expect different deliverables, but these are not clearly explained. It’s not surprising that projects overrun when it’s unclear what the targets are, who should do what, or how it should be done.”

“I don’t think anyone here has been trained on MS Project. I use it my way. It’s a real headache to work with people who use it differently.”

“The change projects aren’t prioritised, so we just do them in the order they come in.”

“Purchasing looks for cost savings with new suppliers, but doesn’t realise that the cost of qualifying a new supplier is more than the cost savings they offer.”

“The Sales organisation needs to get its act together. Recently we developed a great new product but the Sales people forgot to put it in the catalogue so it was never sold.”

“A good product development process, built into software with cockpit charts, guidelines and template documents, would be very helpful.”

“Marketing does portfolio management in the ERP system. I don’t know how it works. We don’t have access. We manage our products in Excel.”

Fig. 2.22 Feedback from interviews with R&D

“R&D don’t seem to be trained. They seem to have no rules, no standard structure for what they give us. We have full-time people to fix their mess.”

“R&D’s tests for new products keep interfering with our plant, costing us downtime for revenue-generating production.”

“We have capacity problems when R&D dumps a big batch of changes to existing products on us.”

“I get so many emails about changes to components and products that I don’t what to do with them. There are so many that I don’t know which ones are important.”

“We make products for all our development sites. Each has different product structures and different document packages. We spend hundreds of man-hours massaging their data into our standard.”

Fig. 2.23 Feedback from interviews with operations

2.6 Product Pains

It’s not easy to manage a product across its lifecycle. A lot of pain can occur (Fig. 2.25). Product development and support involves many variables, relationships and abstractions. They address a wide range of subjects, and are carried out by a wide variety of people using a wide range of practices, methods and applications, working in a wide variety of environments. Converting a concept into a working

Seven different project management systems in use across the company Three different definitions of the product development process Five different applications for Portfolio Management Ten different formats for project management data Five different ways of measuring the length of a project Four different ways of quantifying manpower resources Many different layouts for documents such as the Project Start template No formal documented Portfolio Management process in the company No formal documented Pipeline Management process in the company No global capacity planning management No overall inventory of development projects No overall inventory of development skills At least 50 different report formats for product development projects Five major ongoing corporate improvement projects About 20 ongoing departmental improvement projects No differentiation between small and large projects, or projects for large and small customers No guidelines for Portfolio Management R&D handling over 4000 projects world-wide, an average of more than four per person

Fig. 2.24 Quantitative feedback

Imagine	*Define*	*Realise*	*Support/Use*	*Retire/Recycle*
Ideas pirated	Projects late/ failing	Pollution costs	Upgrades ignored	Incorrect identification
Lack of ideas	Costs too high	Poor factory layout	Missing applications	Poor documentation
Uncontrollable	Uncontrolled changes	Scrap	Poor communication	Low recycle rate
Suppression of ideas	Unclear processes	Rework	Data out of control	Materials wasted
Missing applications	Needs not clear	Costly prototypes	Culture of risk	High disposal costs
Culture of sterility	Design faults	Supplier problems	Customers lost	Fines
Failure punished	Application Islands	High material costs	Liability costs	No training
Bureaucracy	Long time to market	Excess inventory	Missing services	Lack of control
Priority, #1 CYA	Data silos	Limited part re-use	High service costs	Missing applications
Unknown cost	IP lost/missing	Slow ramp-up	Processes unclear	Processes undefined
No training	Project status vague	Safety problems	Product recalls	Lack of procedures
No process defined	Standards ignored	Wrong data versions	Product failures	Costly disassembly

Fig. 2.25 Product pain throughout the lifecycle

complex multi-technology product under these conditions isn't easy. It requires a lot of effort, definition, analysis, investigation of physical processes, verification, trade-offs and other decisions. Building any product is hard. Foreseeing what can go wrong with its use and its end of life is also hard.

The complex, risky, continually changing, uncertain, highly competitive product environment makes life difficult for companies that develop, produce and support products. In such an environment, they need to have great products that leave competitors far behind. They need a great product deployment capability. They need to be continually in control of their products.

If they aren't in control, and for one reason or another, they take their eye off the ball, unpleasant consequences can occur. Customers and other product users may be killed. Billions of dollars may be lost. Executive reputations may be tarnished. Company workers may lose their jobs. When a company loses control of its products and product-related activities, there can be effects (Fig. 2.26) in several areas.

Area	*Effect*
Customers	Deaths and injuries
	Loss of customers concerned about product problems
Financial	Financial losses due to damages resulting from product use
	Reduced profit due to costs of recalls and legal liabilities
	High cost of problem clean-up
	Revenues lost to low-cost competitors
Image	Negative publicity in the media
	Damage to the company's image
Environment	Pollution of the environment
Products	Products not behaving as expected
	Development projects finishing late
	New products not providing competitive advantage
	Resignation of top executives
	Management appearances in court
	Executives sent to prison

Fig. 2.26 Some effects of losing control of a product

Problems occur with products in every industry. The following paragraphs give examples from industries as diverse as aerospace, power, automotive and finance.

2.6.1 Aerospace Products

In 1999, NASA's $125 million Mars Climate Orbiter got too close to Mars and burned up in its atmosphere. An investigation found that a contractor's spacecraft engineering team (in Colorado) supplied information about propulsion manoeuvres in Imperial units (inches and pounds) to the navigation team (in California) which was using metric units.

In 1983, a Canadian Boeing 767 ran out of fuel, and had to glide down to an emergency landing after someone used the wrong metric/Imperial conversion factor to calculate how much fuel it needed to get from Montreal to Edmonton.

The Hubble Space Telescope was a collaborative development of NASA and the European Space Agency. It was deployed in April 1990. Initial images were found to be unexpectedly hazy. Two months later, the telescope was found to suffer from spherical aberration of the primary mirror. In places, the mirror was 2 microns too flat. The problem was corrected with COSTAR (Corrective Optics Space Telescope Axial Replacement) during a service mission in 1993. An inquiry was held into the problem and a technical explanation found. There was a fault in the null corrector, an instrument used in the mirror's manufacturing and testing process. Management failures were also identified. There had been insufficient testing, and under cost and time pressure, contradictory test results from other equipment were not sufficiently investigated. No formal certification had been required for the null corrector even though it played a crucial role. Project managers lacked the expertise required to correctly monitor activities and there was poor communication. COSTAR and the corrective mission are estimated to have cost more than $500 million. Hubble's cost at launch was estimated at about $1.5 billion.

On the morning of January 28, 1986, the Challenger Space Shuttle was destroyed 73 s after launch. The seven-member crew died. It included Christa McAuliffe, who was to have been the first teacher in space. On February 1, 2003 the Columbia Space Shuttle broke up during re-entry. The seven-member crew died. In both cases, there was, of course, a physical reason for the accident, but in both cases the investigators also found organisational problems.

On 2 September 1998, not long after take-off from New York, the flight crew of Swissair Flight 111, an MD-11, noticed an abnormal odour in the cockpit. Their attention was drawn to an area behind and above them, but whatever it was apparently then disappeared. They decided it was smoke and decided to land, unaware of a fire above the ceiling in the front area of the aircraft. The fire spread, degrading aircraft systems and the cockpit environment. The aircraft crashed into the Atlantic Ocean near Halifax, Nova Scotia. The Canadian Transportation Safety Board investigation into the crash found that the accident was probably caused by an arcing event on an in-flight entertainment network cable, which set alight nearby flammable material. The investigation found that aircraft certification standards for material flammability were inadequate. They allowed use of materials that could be ignited and propagate fire. And the type of circuit breakers used in the aircraft wasn't able to protect against all types of wire arcing events.

On March 8, 2014, Malaysia Airlines flight MH370 disappeared en route from Kuala Lumpur to Beijing.

2.6.2 Power Plants

On August 14, 2003, there was a power cut in the north-east of North America. More than 50 million people in dozens of cities including New York, Detroit and Toronto went without electricity all night. Some were trapped in trains and lifts, others were forced to sleep on the streets.

Sometimes the result of losing control of a single product can have world-wide consequences. In April 1986, operators at the Chernobyl nuclear power plant started a simple test run that went wrong. It led to a chain reaction and explosions that blew the roof off the reactor, releasing radioactive products which then travelled round much of the world. Fire-fighters died, hundreds of thousands of people were evacuated, and the incidence of thyroid cancer in local children increased.

That wasn't the first time things had gone wrong with a nuclear power station. In 1979, at the Three Mile Island nuclear power station near Harrisburg, PA, a minor malfunction in a cooling circuit led to a temperature increase causing the reactor to shut down automatically. Unknown to the operators, a relief valve failed to close, much of the coolant drained away and the reactor core was damaged.

The resulting investigation found the causes were deficient instrumentation and inadequate emergency response training.

2.6.3 Automotive Products

In 2001, as a result of high tyre failure rates, Ford Motor Company announced it would replace all 13 million Firestone Wilderness AT tyres on its vehicles. It took a charge of $2.1 billion to cover the costs of replacing the tyres.

In October 2003, Nissan Motor Company said it would recall 2.55 million cars at an estimated cost of 15–16 billion yen ($138–148 million) due to an engine defect.

In a few months in late 2009 and early 2010, Toyota announced recalls of more than eight million cars due to concerns over accelerator pedals and floor mats. The cost was estimated at $2 billion. In January 2010, Honda announced the recall of more than 600,000 cars to fix a switch defect that could lead, in some cases, to a fire.

In June 2010, GM recalled over a million vehicles due to thermal incidents with heated washer fluid systems. In 2014, General Motors announced that it would rework or replace the ignition keys on about 3.16 million 2000–2014 model year cars in the U.S. because the ignition switch might inadvertently move out of the "run" position if the key was carrying extra weight and experienced some jarring event. The "GM 2014 year-to-date North American recalls including exports" chart showed 84 recalls in 2014 with a GMNA & Exports total population of over 30 million.

2.6.4 Financial Products

A home mortgage is a simple financial product. It's a loan from a financial institution to help purchase a property. In return for the loan, the customer agrees to make payments to pay it off, and to use the property as security. The product has a few basic product characteristics, such as loan size, length of loan period, interest rate, and repayment schedule. What could go wrong with such a simple product and such security? Well, financial organisations could offer variable interest rate mortgages to people with no capital, low earnings, and a history of unemployment and loan repayment delinquency. The result was the 2007–2008 global financial and economic crisis. Financial organisations round the world lost trillions of dollars. Some went bankrupt. Many were saved by taxpayer bailouts. Stock markets slumped. People lost their houses, companies closed, global economic growth declined, countries' economies went into recession.

airbags	processed food	cars	infant car seats	baby food
water heaters	bicycles	bunk beds	slippers	jackets
toys	television stands	refuse bins	shave gel	door knobs
security phones	cheese spread	chicken salad	cider	cookies
chairs	candleholders	flashlights	refrigerators	rifles

Fig. 2.27 A wide range of recalled products

2.6.5 Other Products

In addition to problems with high-profile products such as aircraft, power plants and cars, there are also, on an almost daily basis, publicly announced recalls of all sorts of products (Fig. 2.27).

In April 2010, an explosion on the Deepwater Horizon drilling rig led to the death of 11 people. The blowout preventer failed to activate correctly. For months, tens of thousands of barrels of oil spilled daily into the Gulf of Mexico, totalling perhaps a hundred million gallons. BP stopped paying dividends to its shareholders, and agreed to finance a $20 billion clean-up and compensation fund. On one occasion, US President Obama was reported as saying he had visited the Louisiana coast, "so I know whose ass to kick".

Merck voluntarily withdrew VIOXX, an arthritis and acute pain medication, in September 2004 because a trial had shown an increased relative risk for cardiovascular events. There were millions of users worldwide. VIOXX had been launched in 1999 and marketed in more than 80 countries. Worldwide sales in 2003 were $2.5 billion.

If products don't meet the rules and regulations laid down by government and international authorities, there can also be problems. In 2001, authorities in the Netherlands found that some peripherals for a game console contained cadmium levels above the Dutch limits. Sony Corp. temporarily halted shipment. The estimated impact on sales was about 100 million euros.

2.6.6 Current and Future Nightmare

Most companies don't have products that cause disasters and get to be front-page news. However, that doesn't necessarily mean that they don't have the occasional problem. Most of the companies I work with haven't suffered from disasters to their products. Usually, they're just looking to improve the business, and make more money for shareholders. When we look in detail at the product environment, we often see the same kind of issues that are identified in accident investigations. There are organisational issues, issues with data, issues with products, issues with processes, and other issues such as IS issues.

In one company, the CEO summarised the situation as "a nightmare". In another company, they called it "a horror story". One COO said that, when he first saw the

high service costs	wasted development resources
communication silos	misalignment of expectations
departmental mentality	Sales/Engineering disconnects
projects coming in late	product development costs rising
cycle times lengthening	poor co-ordination with suppliers
service costs increasing	service performance deteriorating
lack of up-front planning	each department convinced of its superiority
poor scheduling of projects	offer for sale of products that can't be built
not enough focus on products	people in different functions not talking together

Fig. 2.28 Typical organisational issues in the product environment

situation of the company's products, he remembered what Alexis de Tocqueville said on his first day as Minister of Foreign Affairs. "Once I was settled at the Ministry, and the state of affairs explained to me, I was aghast at the number and extent of the difficulties that I saw."

Over the years, I've worked with more than 200 companies. I've seen issues like these in companies of all sizes and in all industries. Many of these companies are highly successful, with some great products and a strong 5-year financial track record.

Usually, taken singly, these issues don't lead to major problems. However, cumulatively they can result in, at best, unnecessarily long lead times, increased product costs and reduced product quality. And, at worst, in disaster.

There are so many issues in the product environment that it's useful to group them to get a better understanding. The groups bring issues together in areas such as business processes, product data, products and organisation. Figure 2.28 shows some typical organisational issues.

There are many issues related to product data (Fig. 2.29). An example is the "data silo", in which the data of one department isn't easily available to people in other departments. Another example is the existence of many Excel spread-sheets containing a lot of different information, often conflicting, about a product.

Frequently, there are also many issues related to products, whether in the factory or in the field (Fig. 2.30). New products may not perform as expected. They may suddenly stop working, or behave in unexpected ways. Interruptions and delays

redundant part numbers	inconsistencies between data in R&D and Support
multiple names for the same project	unsure of material usage across products
product labelling not corresponding to the product	conflicting lists of the configuration of a customer's product
not knowing if maintenance has been carried out	differences in product specifications used by R&D and Sales

Fig. 2.29 Typical data issues in the product environment

rework	errors in product definition records
quality problems	using obsolete components in a new design
high service costs	optimising product layout but causing longer delivery cycles
poor product quality	optimising product performance but fragmenting the supply chain

Fig. 2.30 Typical product issues in the product environment

product release delayed	bureaucratic business processes
slow engineering changes	not enough re-use of existing parts
reinvention of the wheel	increasing rework and engineering changes
inadequate customer service	product labelling not conforming to regulations

Fig. 2.31 Typical process issues in the product environment

hotel coffee machines that don't work	hotel elevators that don't elevate
electronic keys that don't openhotel room doors	sensor-operated doors that don't operate
train toilet-door locks that don't work	vending machines that don't vend
rental cars that unexpectedly stop working	aircraft that can't fly
aircraft that hit another object before take-off	jetways that don't extend
credit cards that don't give credit	taxis that break down en route
reclining aircraft seats that don't recline	cash dispensers that don't dispense

Fig. 2.32 Some products that didn't work as expected

may occur as new technologies and features became available. Technical problems may occur with products in the field.

There are also issues related to business processes (Fig. 2.31). For example, changes may be made to product data by individuals without any co-ordination with other people. Products may meet specifications but fail to meet customer requirements. Often, the experience that a company gains when developing a product is lost, so can't be used when developing the next generation.

Some issues are more difficult to classify. For example, it may be impossible to migrate data from a legacy application to a new application. Many parts, that are either no longer in use or are duplicates, may be maintained in databases. There may be a lack of good product developers. The company may suffer from the Not Invented Here (NIH) syndrome, an unwillingness to benefit from external developments.

The type of issues mentioned above can result in problems with products. Advising companies world-wide, I travel a lot, and get the opportunity to see a lot of products at work. From personal experience, quite a lot haven't work well (Fig. 2.32).

2.7 Product Opportunities

There may be some pains with products, but products are also a source of opportunity for a company. Perhaps it was risky to pursue some of these opportunities when business processes weren't working properly, production was unreliable, and customers complained frequently about products. But that was before PLM.

Area	*Problem*
environment	Global Warming, threatening the flooding of many cities and states
poverty	more than a billion people living on $1 per day
unclean water	more than a billion people living without safe drinking water and electricity
slums	in 2000, about a billion people lived in slums, but according to current trends the number will rise to 3.5 billion by 2050
disease	thousands of people die each day of curable diseases and illness. For example, every day, 6000 children die from diarrhoea, usually caused by lack of clean water. In 2009, according to the World Health Organisation, about 1 billion people were affected by Neglected Tropical Diseases such as schistosomiasis and trypanosomiasis
accidents	according to the World Health Organisation, road traffic crashes kill more than 1 million people, and injure more than 50 million, each year. The annual global cost of road traffic crashes is estimated to be over $500 billion

Fig. 2.33 Problems in need of solutions

2.7.1 Globalisation Opportunity

Globalisation is an opportunity. Globalisation has increased the number of potential customers for many companies. The world headcount continues to grow by more than 100,000 per day, promising even more customers in the future. The world population is expected to rise from 7.5 billion in 2015 to about 9 billion in 2050. Seven billion or nine billion, that's an awesome number of potential customers for a company's existing and future products.

Other global opportunities are for products that can help solve the many problems facing the world (Fig. 2.33).

2.7.2 Technology Opportunities

New technologies offer the promise of new products. New technologies appear and cause such massive change that they are frequently referred to as revolutions. Examples from the last few decades include the Digital Revolution, the Electronics Revolution, the Computer Revolution, the Communication Revolution, the Biotechnology Revolution, the Nanotechnology Revolution, and the Internet Revolution. Each of these revolutions leads to change and opportunities. New technologies open up new markets and lead to new products.

The transistor, which was invented in the late 1940s, led to a seemingly endless stream of electronics and communication products throughout the second half of the twentieth century. The invention of the computer led to other new products such as data storage devices and software applications. Biotechnology appeared in the early 1970s, leading to countless new drugs. Existing technologies such as electronics, computing, telecoms, robotics and biotechnology will continue to offer scope for new products.

And, in 2015, there are many new technologies that offer opportunities for new products.

"seeing", "feeling", "reading", monitoring	with various types of sensors
"speaking"	with a voice synthesiser
moving	with motors
locating	with GPS
showing information	on a display
"thinking and calculating"	with a microprocessor
remembering information	with a memory
self-identification	with a memory
sending information over a network	with a transmitter

Fig. 2.34 Smart functions

There are opportunities with Smart Products. In addition to their primary functionality, these have functionality to decide or communicate about their situation or environment (Fig. 2.34). A washing machine has primary functionality to wash clothes. A smart washing machine, equipped with a scanner, can read the labels on clothes, and select the most appropriate washing and drying cycle. Smart labels in transparent foil around meat products can change colour from blue to red when the temperature rises above the safety limit. A smart lawn mower can be programmed to cut the grass for you. Its sensors see if there are any obstacles, identify the height of the grass, and switch on its motors to go down the garden and cut the grass. A smart microwave oven can identify the food to be cooked, then set the timer and the temperature. A smart water softener can identify the hardness of incoming water, and treat it as required by its hardness and the intended use. Many more examples could be given, there are many opportunities.

There are opportunities with Radio-frequency identification (RFID) technology. Products tagged with RFID chips can provide information about the product when they are scanned. This allows products to be tracked throughout their lifetime. RFID offers opportunities to get a better understanding of the way products behave over their lifecycle. This can be fed into the development of the next generation of products. It can also be used to optimise use of the product. For example, the collection and analysis of information on truck utilisation can allow different maintenance schedules to be applied to individual vehicles based upon the accumulated knowledge.

There are opportunities with Social Technologies. They can be used across the product lifecycle. In the idea phase, they can be used to crowd source for new products and features. Then, they can be used to co-develop the product with an external community. They can be used to facilitate collaboration and knowledge-sharing within the company. Later, they can be used to increase market awareness of the product. And, once the product is on the market, they can be used to respond to customer questions or complaints, and provide fast customer service.

There are opportunities with Mobile Technologies. They can be used across the product lifecycle. Designers of fashion goods can travel worldwide, yet be creative and deliver new designs within minutes of their conception. On-the-move patients involved in trials of new drugs can send performance data rapidly to researchers.

Customers of all sorts of products and services can access product and service information from anywhere. Service workers can connect to a central database from the customer site where they are working. People working in the company can access best practices and latest insights. SMS text messages can be used to support training about new products.

There are opportunities with Big Data and Analytics. Companies create and receive huge quantities of data every day. Some data may come from operations and maintenance. Some may come from sales and service situations. Once all the data has been organised, analytics offer fact-based insight into the entire product lifecycle. The company can use the data to better understand products, and predict what customers want next. Tailored products can be configured to meet customer desires. Analytics offers opportunities to leverage data and deliver deep insights for product managers. For example, operating data from machines can be analysed to minimise downtime and maximise production.

There are opportunities with the Cloud. Some are oriented to customers. For example, new products and services can be offered in the Cloud across the product lifecycle. Other opportunities are oriented to the company's IS offerings. For example, instead of users waiting years for their companies to provide applications on corporate infrastructure, they can rapidly access best-in-class applications on a shared Cloud infrastructure.

There are opportunities with 3D Printing. Product development can go faster as prototypes are made on 3D printers connected directly to CAD applications. Production can go faster as 3D printers go beyond making prototypes to making real parts and products.

There are opportunities with Knowledge Management. For example, many of the first generation of product developers who worked with computers, and implicitly or explicitly defined their companies' information and activity structures and elements, reached retiring age in the first decades of the twenty-first century. Born between 1945 and 1955, these Baby Boomers were among the first users of computers in their companies. By the year 2010 they were in management positions at the heart of their companies' product environments. Between 2015 and 2020, many will retire taking with them the knowledge of why and how many activities in their organisations are carried out, and why particular design and other decisions were taken for specific products. Knowledge Management techniques can ensure that such knowledge is captured and not lost.

The Internet and the World Wide Web offer many opportunities for new products and services, and new ways to develop, sell and support products. The Internet of Things enables companies to see their products across the lifecycle. In the IoT, products are connected to the Web with their own web address, with controllers, performance data and feedback available online. Then for example, over the Web, you can switch on the oven and the heating before you get home. You can open the garage door without getting out into the snow. Companies can offer new services on top of existing products. For example, a vending machine manufacturer can inform soft drinks companies when the stock of drinks in the machine is running low. Machine manufacturers can predict when a device will fail and propose what should be done to avoid problems. Improving security, products, ranging from ships through aircraft to consumer products, can be tracked and unusual situations notified.

2.7.3 Social/Environmental Opportunity

Society has always had an impact on manufacturing industry. Years ago, among the most highly visible effects of manufacturing industry were the factory chimneys and coal-burning fires that polluted cities. From the 1850s, London, England suffered from smog, a mixture of fog and smoke resulting from the combustion of coal. In 1952, a smog led to 4000 excess deaths. This was a key event in environmental history. Laws were passed requiring the use of cleaner fuels. Nevertheless, as late as 1962, London experienced a smog with 340 excess deaths. For a time, London then had cleaner air, but it now suffers from photochemical smog which occurs when sunlight acts on nitrogen oxides in vehicle exhaust gases to form ozone. In addition, incomplete combustion of fuel leads to the production of carbon monoxide, a colourless, odourless, poisonous gas. Having removed industrial pollution from their cities, advanced industrial countries now introduce laws concerning emissions from cars, disposal of cars, and disposal of electric and electronic goods. Other effects of manufacturing industry that are of concern to society include acid rain, global warming and the ozone hole. Initially, in the name of Progress, much is accepted, but eventually society catches up and legislates against dirty, poisonous products that kill and pollute. PLM will play a key role in addressing all these issues because it provides the opportunity to get control of products across their lifecycles.

Sustainable Development was defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” by the Brundtland Commission in 1987. It’s a holistic concept that aims to unite economic growth, social equity, and environmental management. The problems it addresses, and the ideas for their solution, are not new. Over the years, population growth, lack of disposal sites, and scarce natural resources have led to all sorts of reduction, reutilisation, recycling and recovery programs. It’s easy to over-exploit natural resources such as oil, water, farmland, fishing grounds, forests and minerals. It requires more thought to use them in a sustainable way.

2.7.4 Human Resource Opportunity

In 2015, companies are hiring people from the Millennial Generation, born between the early 1980s and the early 2000s. Unlike previous generations, they’ve grown up in a digital world of computers, Internet, the Web, smartphones and other digital technologies. Many are cyborgs, with implanted chips. They can use technologies and see opportunities that are invisible to many members of previous generations.

2.7.5 The Result and the Requirements

The result of the many changes mentioned in this chapter is a complex, risky, continually changing, uncertain, highly competitive, global product environment. This is characterised by demanding customers, horizontal integration across the Extended Enterprise, many small and medium companies in the design, supply and support chains, few layers of management, ubiquitous computing, fast technological evolution, and small numbers of knowledge workers from different functions working together in collaborative teams.

There's growing competitive and legislative pressure, such as that concerned with product liability, deregulation, health, safety and the environment. There are technology issues to be faced, including the effect of the increasing amount of electronics and software in products, the possibilities offered by the Web, nanotechnology, and the rapidly decreasing cost of computer power.

To be successful in this environment, a company must be able to supply and support the products that customers want when the customers want them. The company must have great products and it must have a great product deployment capability. Customer expectations are rising. But there's also increasing consumer resistance to price increases. Product costs must be trimmed so that they correspond exactly to customer requirements. Product functionality must be improved to match these requirements. Customer service must be improved with on-time documentation delivery, reliable delivery times, prompt complaint handling, and easy product repairability.

Products must be brought to market faster. Technology is evolving fast. Products are becoming obsolete sooner. As product lifetimes get shorter, significant market share is lost if a product isn't brought to market at the earliest possible moment. A company that gets to market first can capitalise on late market entry by competitors.

To successfully meet, in a complex, changing environment, these requirements for great products, companies need PLM. It has the potential to solve the problems throughout the product lifecycle. And it enables companies to seize the many market opportunities for new products in the early twenty-first century. PLM allows companies to develop and support tiptop services and products across the lifecycle. The Good News about PLM is that it offers companies the opportunity to address larger markets, to develop a great product, sell it to billions of customers and users, and rack up huge profits.

2.7.5.1 Next Steps

The first two chapters of the book provided an introduction to PLM and an introduction to the environment before PLM. In the next chapters, the Five Pillars of the PLM environment are addressed:

- Business Processes in the PLM Environment (Chap. 3)
- Product Data in the PLM Environment (Chap. 4)

- Information Systems in the PLM Environment (Chap. 5)
- Organisational Change Management in the PLM Environment (Chap. 6)
- Project Management in the PLM Environment (Chap. 7)

And then, Chap. 8 describes the PLM Initiative.

Chapter 3
Business Processes in the PLM Environment

3.1 This Chapter

3.1.1 Objective

The objective of this chapter is to give a basic introduction to business processes as they relate to a company's PLM environment and PLM Initiative. This will help those in a company's PLM Initiative to understand process-related topics and participate more fully in the PLM Initiative. This chapter also aims to give students a basic understanding of the business process component of a company's PLM environment.

3.1.2 Content

The first part of the chapter is an introduction to business processes in the PLM environment. It describes the purpose, role and importance of processes across the product lifecycle. Definitions are given of frequently used terms in the business process environment. The different approaches to managing business activities in the twentieth century and the twenty first century are described. Examples are given of processes, and of the tools and documents that are used to manage them. The need for business process modelling is introduced. Different types of process flow diagram are described. Use cases and workflows are addressed. Required characteristics of processes, including KPIs, are outlined.

The second part of the chapter addresses business processes in the PLM environment of a typical company. It describes typical process issues that are encountered in many companies. The interaction with other components of PLM, and with other company initiatives is addressed. The process challenges that occur in a typical PLM Initiative are described. A generic vision is given for the business process component of PLM.

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The third part of the chapter describes typical projects in the PLM Initiative that are related to business processes. The need for business process improvement is described. Critical Success Factors for process improvement are described. Examples of process-related projects are given. Business process mapping and modelling activities are addressed. Guidelines are provided for process mapping. Other examples of process-related projects address the Engineering Change Management, New Product Development and Portfolio Management processes.

The fourth and final part of the chapter builds on experience of working with business processes with many companies. It shares lessons learned from experience in PLM Initiatives. An approach to business process improvement is outlined. The pitfalls of process modelling are described. Top management's role in the management and improvement of business processes is addressed.

3.1.2.1 Skills

This chapter will give students, in classes for which this book has been assigned, a basic understanding of business processes in the PLM environment. They'll learn what a business process is and why it's important. They'll be able to explain, communicate and discuss about business processes and related activities in a PLM Initiative.

In addition, they'll learn how business processes are documented. They'll know about business process mapping and modelling. They'll learn about the problems and opportunities with business processes in the PLM environment of a typical company. They'll be able to describe the typical activities of a process improvement sub-project in a PLM Initiative. And they'll be aware of some companies' experience with business process improvement sub-projects in PLM Initiatives.

3.1.3 Relevance of Business Processes in PLM

Business processes are a main component of the PLM Grid (Fig. 1.5). They contain all the company's knowledge about how to design, manufacture, support, use and recycle a product. A business process describes how the company wants to work on a particular activity. Put together, all the business processes of a company show how the company wants to operate.

Companies have a choice. For example, they can work with a New Product Development process with which it takes 18 months to get a product to market. Or they can improve the process and get the product to market in 9 months. They can have a New Product Development process that doesn't include Risk Management, and then waste time and effort fire-fighting when issues arise in NPD projects. Or they can include Risk Management in the process and avoid the issues.

A business process defines the tasks that people will do to achieve a business objective (e.g., develop a new product). Ideally, the tasks in the process would

Fig. 3.1 Requirements for business processes

under control	high quality, accurate, complete
lean, waste-free	well-documented
well-trained	considered as a strategic company asset

involve the minimum of effort required to achieve the objective. However, in practice, it could also include tasks that add no value, but add to the cost and time of achieving the objective. Companies that want to perform well in activities across the product lifecycle don't want waste in their processes. But, before they can eliminate the waste, they need to understand the processes.

If they are effective, business processes will provide a competitive advantage. If they aren't, then increased costs will result. The quality of the business processes across the product lifecycle is a key element of product success. Errors and/or waste in these processes can cost millions of dollars and waste months of time.

Business processes enable the company to develop, sell and support the product effectively. If a change is needed to the product, for example because of changing laws or regulations, an effective process will enable quick change. If the company can't control its business processes, it will find it difficult to manage its products.

The requirements for business processes are clear (Fig. 3.1).

If business processes aren't managed effectively, the result will be wasted time, rework costs, and slow time to market. Business processes don't look after themselves, and like anything that's not properly organised and maintained, won't perform as required. Over time, they will slide into chaos and decay. However, this has to be avoided as the slightest error in a process can have serious consequences for the product and those associated with it. Getting business processes organised, and keeping them organised, are major challenges in PLM.

3.2 Definitions and Introduction

3.2.1 Definitions

3.2.1.1 Process

The *ISO 9000 Introduction and Support Package*: *Guidance on the Concept and Use of the Process Approach for management system*s document defines a process as a "set of interrelated or interacting activities, which transforms inputs into outputs".

3.2.1.2 Business Process

A business process is an organised set of activities, with clearly defined inputs and outputs, which creates business value.

Within each of the activities there are usually tasks, roles, responsibilities, checklists, milestones, deliverables and metrics that specify in detail the scope, nature, type, information needs, resources, required skills and measurement of work.

3.2.1.3 Process Mapping

The term Process Mapping is usually used to describe the activity of documenting an existing process. This activity is also sometimes referred to as Business Process Mapping, or Process Charting, or Process Flow Charting.

3.2.1.4 Process Modelling

The term Process Modelling, or Business Process Modelling, is usually used to describe the activity of creating models of future processes.

3.2.1.5 Business Process Management

Business Process Management (BPM) is an overall approach to the improvement of a company's business processes. It includes process mapping, process modelling and process measurement.

3.2.1.6 Methods/Techniques/Best Practices

A method (also sometimes referred to as a technique or a best practice) is a recommended way of carrying out a particular set of activities. There are more than a 100 methods related to products. They range from very technical methods to broad-brush management approaches. Examples include Activity Based Costing (ABC), Design for Assembly (DFA) and Total Quality Management (TQM). Methods are often referred to by a Three Letter Acronym (TLA). However this isn't the case for methods such as Plan-Do-Check-Act (PDCA) and Value Analysis (VA).

3.2.1.7 Use Case

A Use Case describes, from the user viewpoint, the interaction between a user of a system and the system. The interaction is made up of many individual actions. A Use Case can be used, during system design, to show expected behaviour and to clarify requirements.

3.2.1.8 Workflow

A workflow (or application workflow) is a small set of connected actions that are frequently carried out, and has been automated in a particular application. The actions will normally have been defined in a Use Case.

3.2.2 Action Across the Product Lifecycle

There's a lot going on in a company as a product is developed, manufactured, supported and retired. Figure 3.2 shows some of the things that have to happen if everything is to work well with the product across the lifecycle.

Although there are 35 activities in the table below, they are just a small sample of the activities that occur in the product lifecycle. Figure 3.3 shows another 35 activities.

It would be possible to show a few more tables of 35 activities. However the intention isn't to list hundreds of activities. The intention is just to show that there are very many activities in the product lifecycle. And, with so many activities, it should be clear that they will have to be organised.

3.2.3 Organising the Action

For a company to function effectively, it has to manage all of the activities across the product lifecycle.

manage projects	capture product ideas	screen ideas	evaluate proposals	prioritise projects
identify requirements	specify products	define BOMs	define Design Rules	design products
cost products	purchase parts	simulate parts	test parts	manage orders
configure products	plan Manufacturing	make parts	assemble parts	use products
get feedback	solve problems	make changes	replace parts	maintain products
refurbish products	compare actual costs	hire people	upgrade equipment	retire products
disassemble products	recycle parts	train people	report progress	measure progress

Fig. 3.2 Examples of product-related activities in the lifecycle

alliance management	contract preparation	contract review	corrective action	delivery
risk management	design control	disposal	document control	service provision
change management	handling	inspection	leadership	operations
analysis	packaging	process control	supplier audit	integration
project management	prototyping	validation	quality assurance	quality control
equipment purchase	progress review	machine set-up	plant maintenance	verification
product modification	acquisition	project planning	part storage	disposal

Fig. 3.3 More product-related activities in the lifecycle

3.2.3.1 Departmental Focus

For most of the twentieth century, companies were mainly organised by functional departments such as Marketing, Engineering, Manufacturing and After-Sales. People were assigned to a department. Each of the activities listed above was assigned to a department. Then, for example, people in Engineering did the work the way the boss of Engineering told them to work. And people in Manufacturing worked the way the boss of Manufacturing told them to work. In the 1970s, most activities were carried out in this way.

Products were developed in serial separate steps, starting with design and engineering. The Engineering Department did all its work alone, then "threw the design over the wall" to the Manufacturing Department. As a second step, manufacturing engineers tried to work out the best way to produce parts. Once this had been done, the purchasing department would look for the best sources of parts. Eventually an attempt would be made to manufacture the product. Manufacturing would find all sorts of problems with the design, and send it back to Engineering for improvement. Design errors and incompatibilities would then be seen, and much time and money spent on making the necessary changes.

3.2.3.2 Method, Technique, How-to, Best Practice

A departmental structure may make it easy to organise people, and tell them what to do. However, it doesn't truly reflect the way that a company works. In reality, a lot of the activities that take place across the product lifecycle involve people from many departments working together. If some people are working one way (for example, the way the Engineering VP tells them to) on one of these activities, and others are working another way (for example, the way the Manufacturing VP tells them to), there will be confusion. Errors will result. Time will be wasted.

By the late 1970s, companies were looking for ways to overcome the problems of serial, departmental work. The first "methods" appeared. Sometimes referred to as techniques, or best practices, they were recommended ways of carrying out particular sets of activities.

Among the methods were Concurrent Engineering and Simultaneous Engineering. In its December 1988 report "The Role of Concurrent Engineering in Weapons System Acquisition", Concurrent Engineering was defined by the Institute for Defense Analysis (IDA) as—"… a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements." Concurrent Engineering and Simultaneous Engineering, with their emphasis on product teams made up of individuals from different departments and even different companies, and parallel working on processes that were previously carried out in series, aimed to overcome the disadvantages of the previous serial approach.

Another set of methods that appeared is known as DFX (Design for X). The intention of DFX methods is to ensure that, during the design phase of a product, account is taken of the requirements of “X”. For example, DFM (Design for Manufacture) aims to ensure that, during the design phase of a product, account is taken of the requirements of Manufacturing. Methods in the DFX group include Design for Assembly (DFA), Design for Cost (DFC), Design for the Environment (DFE), Design for Recycling (DFR), Design for Repair (DFR), Design for Six Sigma (DFSS), Design for Sustainability (DFS) and Design for Testing (DFT).

Another set of methods that appeared is the EXI group. These methods aim for earlier involvement of people who would previously have been involved much later in a serial development approach. Examples include Early Manufacturing Involvement (EMI), Early Purchasing Involvement (EPI) and Early Supplier Involvement (ESI).

A third group of methods is the LCX group. These methods aim to encourage their users to take account of the life cycle of a product. Methods include Life Cycle Analysis (LCA), Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Life Cycle Design (LCD).

3.2.4 Process Approach

Towards the end of the twentieth century, another move away from the serial, departmental approach occurred. Companies began organising another way, grouping the activities into business processes, and organising around these processes. Since the 1980s, the ISO 9000 family of standards has underlined this process focus.

A process approach is one of the eight principles for a company’s quality management system (QMS) recommended in the *ISO 9001:2008 Quality management systems—Requirements* document (Fig. 3.4).

3.2.4.1 No Standard Processes

Several ISO standards indirectly address business processes in the PLM environment. ISO 10007, “Quality management systems—Guidelines for configuration management”, is an example. However, these documents don’t provide standard processes or describe processes in detail. As their titles suggest, they are more at the level of requirements and guidelines. According to ISO 9001:2008, “All

Fig. 3.4 ISO 9001’s eight principles for a company’s QMS

customer focus	system approach to management
leadership	continual improvement
involvement of people	factual approach to decision making
process approach	mutually beneficial supplier relationships

requirements of ISO 9001:2008 are generic and are intended to be applicable to all organizations, regardless of type, size and product provided."

In the absence of standard processes, each company has to define its own business processes. Business processes define the way a company behaves. They are an important part of a company's make-up, and can be a performance differentiator between companies. Even in regulated industries, companies aren't forced to follow exactly the same processes. Instead, they define their own processes, taking account of regulations, with the objective of performing as effectively as possible.

3.2.4.2 Business Process Architecture

The high volume of action across the product lifecycle results in there being many processes, of different size and importance, in a company. There are actually so many processes that companies take steps to organise them. Companies usually position the processes in a Business Process Architecture with a hierarchy of business processes, processes, sub-processes, sub-sub-processes and activities. At the highest level of the hierarchy are the business processes. A correctly-organised, coherent process architecture will enable effective working across the product lifecycle. It's a common reference for everyone in the company when thinking about processes.

Processes may be divided into three groups. These are operational processes, support processes and management processes. Operational processes create value for external customers. Support processes create value for internal customers. Often, at the top level of the Business Process Architecture, companies include the Management processes, three main Operational processes, and a set of Support processes (Fig. 3.5).

The three main operational processes are Supply Chain Management, Customer Relationship Management, and Product Lifecycle Management. The Product Lifecycle Management process runs from Portfolio Management to Phase Out.

Companies are in such different businesses that they don't have exactly the same processes in the PLM environment. Product-oriented, project-oriented, and order-oriented companies, for example, would be expected to have different PLM processes as they have very different activities. At a high level, though, there are six product-related processes that are found in most companies. Five of them correspond to the five phases of the product lifecycle. These are the Product Idea process, the Product Definition process, the Product Realisation process, the Product Support process, and the Product Phase Out process. In addition there's a Product Portfolio Management process.

3.2.4.3 Process Management

There are so many business processes, and it's so important to get them working right, that many companies have a special Process Group to define, maintain and improve processes.

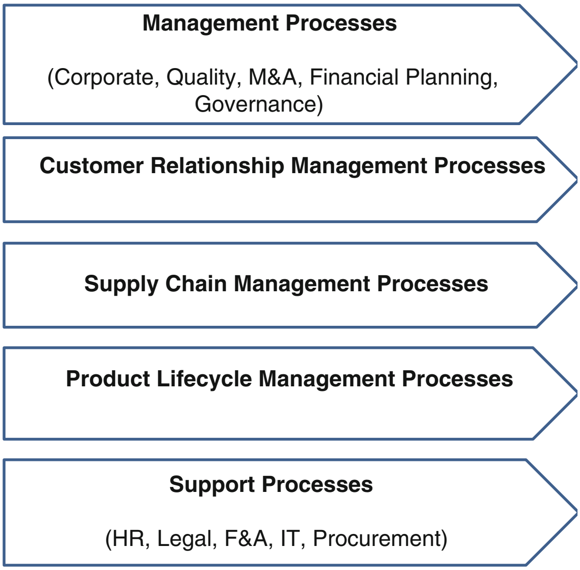


Fig. 3.5 Example of business process architecture

To manage the processes, there are special processes for establishing, defining, documenting, publishing, maintaining and improving business processes. These include sub-processes for planning, review, measurement, audit, monitoring, verification and validation.

3.2.4.4 Needed Characteristics of a Process

It’s often said of PLM that the devil is in the detail. Business processes are no exception. There will be problems unless all the details are right. There are several things about a process that need to be clearly defined (Fig. 3.6).

The purpose of a process, its objective, needs to be clear. If it’s not clear, then people will get confused. They won’t be sure about what they’re doing, or should do, and they won’t work as effectively as possible.

The scope of a process needs to be clear. Its boundaries should be clear. The start point and the input need to be clear. The end point and the output need to be clear.

Fig. 3.6 Examples of process characteristics

name	activities
purpose	location, neighbours
scope	customer
start point, end point	owner
input, output	KPIs

The position of a process in the company's process architecture needs to be clear. It needs to have the right neighbours. Communication with its neighbouring processes needs to be clearly and correctly defined.

The activities of a process need to be clear, as do the participants in the process, the roles of the participants, the information they use and create, and the tools they use. Anything that isn't clear will lead to hesitation and confusion. As a result, time and money will be wasted.

Each process must have a customer. If nobody's going to use the output of a process, then the process doesn't need to exist. The customer of a process may be an internal customer (inside the company) or an external customer (outside the company). The process must add value. Otherwise it's not needed.

Each process needs an owner who is responsible for its performance and improvement.

Each process needs metrics, or Key Performance Indicators (KPIs), so that process performance can be measured, reported, analysed and improved. Determining what to measure, and how to measure it, are key initial activities of process management. Some of the KPIs that are chosen are likely to be process-oriented KPIs, such as the number of documents in a process, or the number of steps in a process. Some KPIs are likely to be business-related KPIs, such as the time it takes to execute the process. And some KPIs are likely to be product-related KPIs such as the number of product defects resulting from a process.

3.2.4.5 Naming of Processes

At the highest level, a process is often identified as the "XYZ Process" (Fig. 3.7). However, at lower levels, since processes describe activities, descriptions need to start with a verb, for example, "Create a list of new ingredients".

3.2.4.6 Particularities of Business Processes in PLM

The business processes in the PLM environment are more complex than those in other areas of a company.

the Intellectual Property Management Process	the Disposal Process
the New Product Development Process	the Phase-Out Process
the Engineering Change Management Process	the Test Process
the Discovery Process	the Retirement Process
the Assembly Process	the Disassembly Process
the Requirements Management Process	the Risk Management Process
the Concept Development Process	the Refurbishment Process

Fig. 3.7 Some processes in the product lifecycle

Business processes in the PLM environment take much longer to execute. It may take 2 years to execute the New Product Development process. Whereas, it may take 2 s to prepare and send your monthly phone bill.

The information structures in business processes in the PLM environment are more complex. For example, the information structure of a car made of 20,000 parts is more complex than that of the monthly invoice you receive from your telephone company.

Business processes in the PLM environment contain many more tasks. The New Product Development process may contain hundreds or thousands of tasks. In other areas, the processes may contain just a few tasks.

In the PLM environment, most of the business processes will be company-specific. In other areas of the company, for example, that of preparing the company accounts, many companies will work to an international standard, for example, the International Financial Reporting Standards (IFRS).

In the PLM environment, descriptions of most of the business processes will contain a lot of technical terms and company-specific jargon that makes no sense to the uninitiated. In other areas, the words used in the business processes will either be drawn from everyday language or based on standard terminology.

In the PLM environment, business processes are often industry-specific, product-specific and company-specific. There is little in common between the details of a Product Maintenance process for a military aircraft manufacturer and the details of a Product Maintenance process for a soft drinks manufacturer.

3.2.4.7 PLM Process Particularities, but Similar Management

Although business processes in the PLM environment are different from those in other areas of a company, they are managed in the same way. The process objective has to be defined. The process has to be documented. Meaningful Key Performance Indicators (KPIs) have to be defined. Targets have to be set. People have to be trained to work in the process. Performance has to be measured. KPIs have to be reviewed to see if the business process is performing as expected.

3.2.4.8 Consequences of Neglecting Processes in the PLM Initiative

If you don't look at business processes in a PLM Initiative, you won't know if the business activities you're executing are as effective as possible. You won't know if the product is being managed effectively across the lifecycle. You won't know if people in the processes are wasting their time on tasks that add costs and time. If you don't regularly review the processes, you can expect the amount of wasteful activities in the processes to increase. You can expect that process performance will get worse.

In a PLM Initiative, someone will usually suggest a new application. Others will immediately agree. Yes! That sounds great! It will improve performance! But, if the business processes aren't known in detail, how can anyone know if the application will actually improve performance? How is the application going to meld with the tasks, product data, people and applications of the existing process? For example, input data for the application has to come from somewhere and be in a certain format, so a new interface will be needed. Similarly, output data from the application will be used elsewhere, probably in a different format, so another interface will be needed. Or will the data be entered by hand (risk of error, waste of time, increase of cost)? Will new tasks, adding no value, be added to the existing process to allow data to be exchanged between the different data formats? Another possibility is that part of the work done by the new application is already done by tasks in the existing process. If you don't review the process, you won't know this, so you'll do the same work twice.

By looking in detail at existing business processes, you see the product data and documents that are really used. Then you have several options to improve performance. You could just put this data in your PDM system. Or you could try to improve the process. And then you could define the documents and the data for the new process. Then you could put them in the PDM system. But if you don't look in detail at existing processes, you may never know what should be in the PDM system.

3.2.5 Tools to Represent Business Processes

It's possible to make a model of a business process with simple tools such as a pencil and a piece of paper. Tools such as Excel, PowerPoint and Visio can also be used to document the current and future process situations. These tools may not seem highly sophisticated. However, they're widely available, usable by most people, and understandable by most people.

There are, of course, more sophisticated applications that include specific functionality for process mapping and improvement. However, they often require additional training and licensing. And if someone doesn't understand the basics of process mapping in Visio, they're unlikely to understand it in a more sophisticated application.

It's relatively easy to map processes in PowerPoint (Fig. 3.8), starting from the top level and working down.

Hierarchical decomposition is a frequently-used approach in process modelling. Starting at the top level (Level 0), the main activities at the next level down (Level 1) are identified. Usually between 4 and 7 activities are identified at Level 1. Then, the same technique is applied at the next level down. For each of the activities at Level 1, the main tasks at the next level down (Level 2) are identified. Again, usually between 4 and 7 tasks are identified for each activity. In Fig. 3.9, "Develop New Product" is at Level 0. There are five main activities at the next level. One of these is "Identify Concepts, Select Best Concept". This is made up of seven tasks at the next level down.

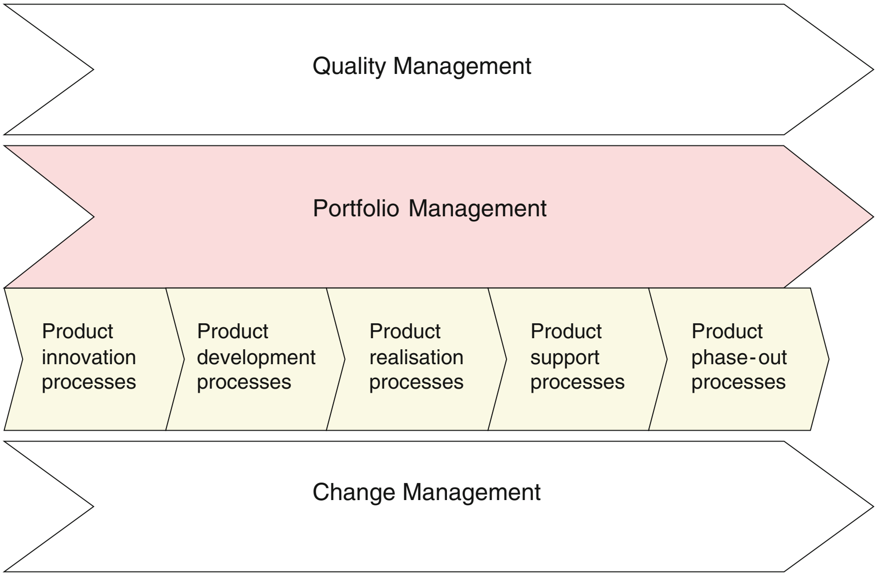


Fig. 3.8 Top-level process layout

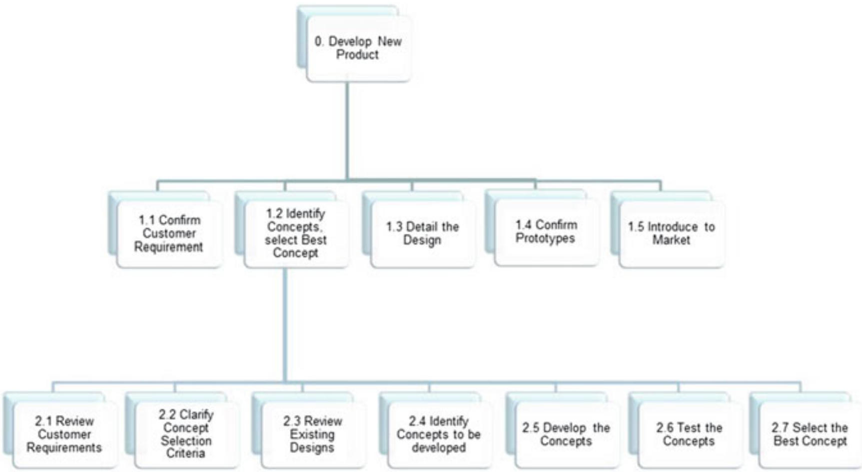


Fig. 3.9 Hierarchical process decomposition

A similar approach can be taken using Excel. In this case, though, instead of laying out processes across a slide, they can be listed vertically in the cells of a column. There is more room available with Excel, so the process name can be included in an adjacent cell. Other cells across the row can be used to document information such as the process owner, the participants in the process, the input, the deliverables, the workload, the value, and the average time spent in the process.

3.2.5.1 BPMN

PowerPoint and Excel are widely available and easy to use for process representation. However, they have limited functionality for process representation. And the graphic objects (boxes, lines, etc.) that one person creates with these tools can have whatever meaning that person wants. The result can be that other people won't be able to understand the resulting diagram.

This problem can be overcome by using a standard notation for modelling business processes, such as BPMN 2.0. This has special pre-defined symbols for activities, conversations, events, gateways, artifacts, data objects, swim lanes, participants, orchestrations, choreographies, collaborations, sequence flow, groups, pools, etc. It was developed specifically for modelling business processes, and was adopted as a standard by the Object Management Group (OMG) in 2006.

3.2.6 Documenting Processes

3.2.6.1 Reasons for Documenting Processes

There are several reasons for documenting a company's business processes (Fig. 3.10).

3.2.6.2 Models

The scope of the PLM environment is wide. It's a complex environment. It's difficult to understand. Simple models are needed to help people understand and communicate about it. A model of the PLM environment acts as a common basis for discussion and communication. It helps people increase understanding and reach a common view.

Many different models can be developed. For example, a model could show how product data is created and used in business processes by people from different departments using different applications. Models can show the situation at different

to define how a company wants to work	to retain knowledge. One day, employees leave
to explain the process	to assure quality, "this is the right way to do it"
to achieve compliance	to show how a company's processes fit together
to make it easy to train new employees	to understand the process as a first step to improving it

Fig. 3.10 Reasons for documenting business processes

times, and from different viewpoints. Some of these models are complementary. Companies often find that it's useful to create models of both the current ("as-is") situation and the future ("to-be") situation. These will eventually be related by a plan.

Another useful pair of models is the "top-down" model and the "bottom-up" model. The "top-down" model is developed from a business-oriented overview of the PLM environment, working down towards individual operations and detailed descriptions of data and activities. The complementary "bottom-up" approach starts from individual operations and detailed descriptions of data and activities. Then it links data and operations, and builds successively higher levels of information and processes.

3.2.6.3 Process Flow Diagrams

A simple list of process steps for a process wouldn't show the interactions between tasks. It wouldn't show the different routes the flow may take when a decision is taken. Interactions are easier to show in flowcharts. These may be presented horizontally or vertically (Fig. 3.11).

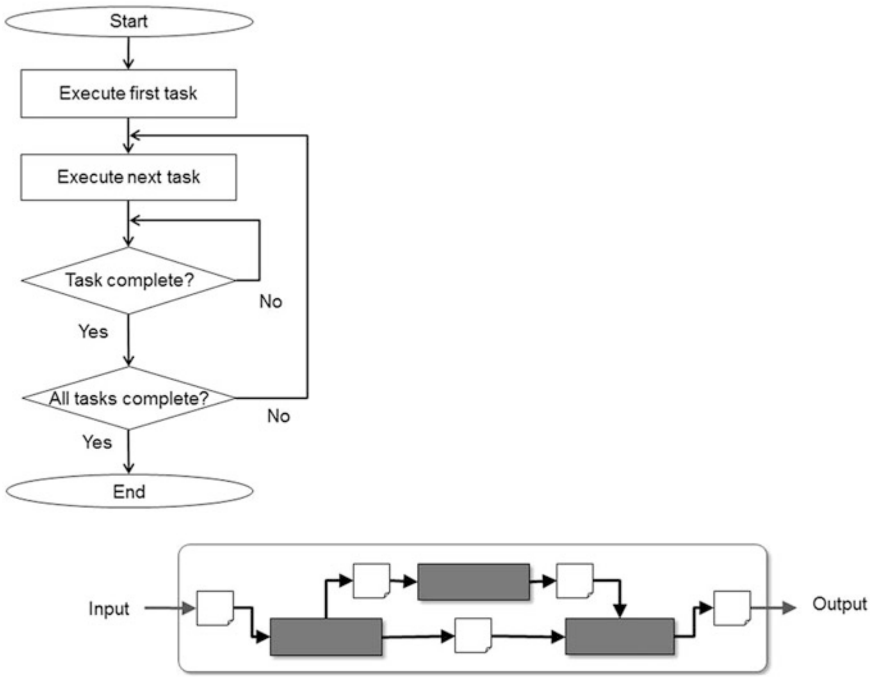


Fig. 3.11 Vertical and horizontal flowcharts

3.2.6.4 Swimlanes

Another way of modelling a flow of activities is to show them in "swimlanes" (Fig. 3.12). This approach allows information about the roles of participants ("actors") to be shown. It shows the flow of activities, including the activity of taking a decision.

The swimlane example (Fig. 3.12) shows roles and activities. It has a swimlane for each role. Adding a swimlane for a PDM application makes it possible to link an activity with the data it uses (Fig. 3.13).

The swimlane diagram could be of the current situation, or of the desired future situation. In either case, it will help people understand what happens in the process, who does what, what data is used, and so on. The diagrams can be annotated to show who participated in their development, and who validated them. This will help get everyone on the same page. It will also show that everyone involved is on the same page. The diagrams can also be annotated to highlight the position of strengths and weaknesses, and opportunities for improvement.

3.2.6.5 Process Description Documents

One part of a company's process documentation usually includes a top-down description of how the business processes fit together (the company's Business Process Architecture). Another part of the documentation addresses each process in detail.

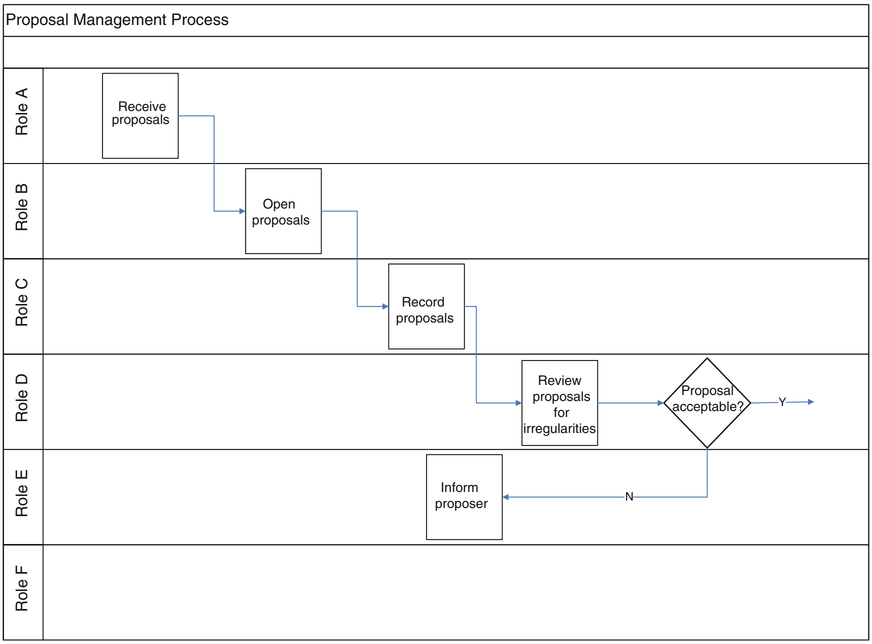


Fig. 3.12 Activities in swimlanes

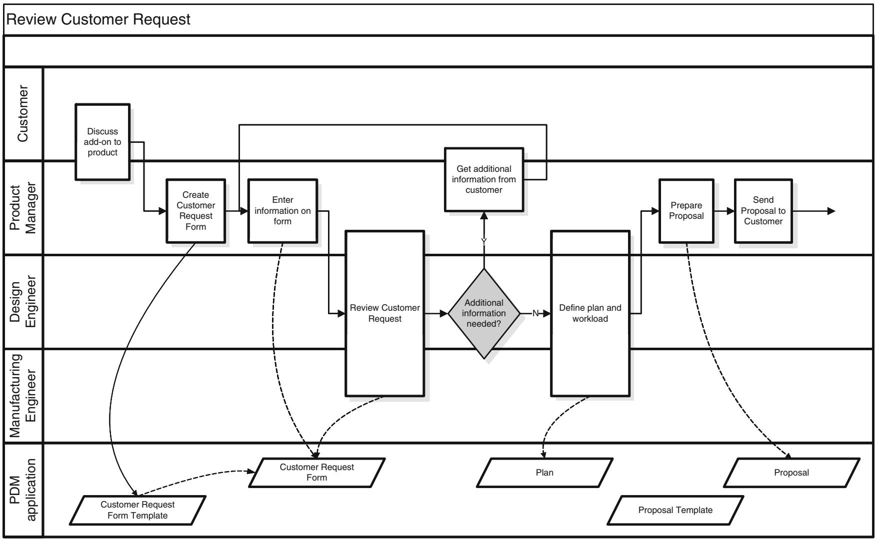


Fig. 3.13 Activities and data in swimlanes

For each process, there should be a process description document. This document provides guidance to participants on how to carry out the activities in the process. Process descriptions are usually several pages long, and include several sections (Fig. 3.14).

The process description document nearly always contains a process flow diagram. This may be in any one of several formats. There could be a simple flow diagram showing the main activities. Alternatively, there could be a table listing the name of each activity in the process, its input and output, the participants, any special methods used, etc. Another possibility is a basic swimlane diagram showing roles, activities and documents. Sometimes a more complete swimlane diagram is provided, showing roles, activities, documents and a lane for data management.

3.2.6.6 Process Steps

The process description document usually shows the main steps in the process. For example, the Product Complaint Process, the process to handle complaints made by customers about the company's products, could contain 11 steps (Fig. 3.15).

1	process name	8	process step description
2	document name, number, revision, date	9	metrics
3	purpose	10	forms
4	scope	11	IT systems
5	terminology definitions and acronyms	12	special techniques
6	process flow diagram	13	responsibility and authority
7	participant responsibilities	14	references

Fig. 3.14 Sections of a process description document

1	the customer fills in the Complaint Form and sends it back to the manufacturer with the defective product
2	the company's Quality Department receives the Complaint Form and the product
3	the Quality Department carries out an initial review of the form and the product
4	the Quality Dept. determines required next steps, creates an investigation plan, and launches next steps
5	the Production Department receives the Complaint Form and samples
6	the Production Dept. carries out a review, and decides if the problem is Production-related
7	the Production Dept. sends the Complaint Form and samples to the R&D Department
8	the R&D Department carries out a review and identifies the root cause
9	the R&D Department informs Customer Service
10	the Customer Service Department sends a reply to the customer
11	the customer receives the reply, is satisfied with it, ... and continues to buy the company's products

Fig. 3.15 Some steps of a product complaint process

The list of steps in the complaint process shows some of the tasks that may be in the process. It also raises questions that will need to be addressed during process design and description. For example "is the process different for different levels of defect severity?" Other questions will be asked. "How much time do we have to respond to the customer?" "If this is a known problem, do we need to identify the root cause again?" "For what types of complaint do we need to involve top management?"

3.2.6.7 Use Case, Use Case Description

Another type of activity documentation is a Use Case Description.

A Use Case describes, from the user viewpoint, the interaction between a user of a system and the system. It can be used during system design to show expected behaviour and clarify user requirements.

As an example, a Use Case could describe the login to a system. The first lines of a first draft might look like Fig. 3.16.

Some people may wonder why such details are needed. The reason is that unless they are documented and agreed, the user requirements are unlikely to be met. The user may have one set of activities in their mind. The system developer may have another set of activities in their mind. It's only by documenting the interaction, and discussing it, that the user and the system developer can be sure they have the same picture.

A standard format is often used for a Use Case Description (Fig. 3.17). This format helps to make sure that the description is complete. And it makes it easier to write, communicate and agree about Use Cases. The required information often

the system user starts the application
the application requests a user name and a password
the user enters a user name and a password
the system validates the user name and password, and presents the initial screen

Fig. 3.16 First lines of a first draft of a use case

Fig. 3.17 Use case description

```
Use Case Number:
Use Case Name:
Version:
Description:
Purpose:
Actors:
            <Actor 1>
            <Actor 2>
Assumptions:
Pre-conditions:
Normal Flow of Events:
            <Step 1>
            <Step 2>
            <Step 3>
            <Step 4>
Post-conditions:
Alternative Flow:
            <Step 1>
            <Step 2>
            <Step 3>
Special conditions:
Notes:
```

includes information such as: Use Case Name; Use Case Purpose; Actors (such as document author, document approver); pre-conditions/Initial State/Start Conditions of the Use Case; Use Case Steps; the End State/Post-Conditions of the Use Case; and exceptions or variants.

The four lines of Use Case (Fig. 3.16) describe how the system validates the user name and password, and presents the initial screen. Hopefully that would be the Normal Flow of Events. But it's also possible that the system can't find the user name and/or password, or considers the password to be invalid. For that case, an Alternative Flow needs to be documented.

Many Use Cases are needed to define the scope of a complete system.

3.2.6.8 Use Case Diagram

A Use Case Diagram is one of the three Unified Modelling Language (UML) behaviour diagrams.

UML is a commonly-used modelling language. It's described in ISO/IEC 19501:2005. Use Case Diagrams are described in Part 6.

A Use Case Diagram (Fig. 3.18) brings together several Use Cases. It describes graphically the interaction between a user of a system and the system. The users, the "actors", are represented by matchstick people. A Use Case is shown in an oval.

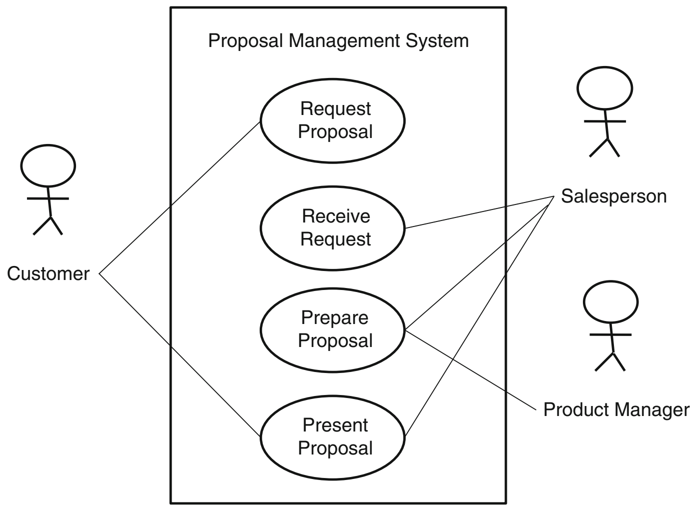


Fig. 3.18 A use case diagram for a proposal

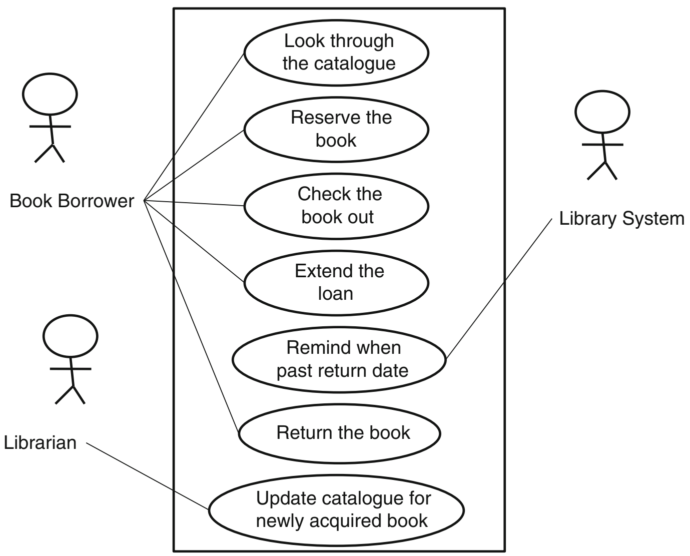


Fig. 3.19 A use case diagram for a library

Sometimes, as in Fig. 3.18, a Use Case Diagram shows the actors outside the system. Sometimes, as in Fig. 3.19, a Use Case Diagram shows the system as an actor.

Use Cases are needed in many areas (Fig. 3.20) to describe the detailed interaction between an application and a user.

start-up of session	import assembly data	create PDF of released document
authentication	export assembly data	publish documents to intranet
data input check	deviation reporting	archive a product structure
create an ECR	integration with ERP	data handover to customer

Fig. 3.20 Examples of subjects for use cases

3.2.6.9 Creation of Workflows

A Use Case can be used as a basis for building a workflow.

A workflow is a small set of connected actions that are frequently carried out to accomplish a particular goal, and have been automated in a particular application. An example is a workflow for document creation. Other examples are application workflows for document approval and for document change.

There are clearly defined steps and roles in a workflow. Activities are carried out, in a pre-defined order, using pre-defined documents, by the people in those roles working according to pre-defined rules.

A workflow overcomes some of the difficulties of carrying out a set of actions in a purely paper-based environment (Fig. 3.21). Consistency is achieved though pre-defined rules, procedures, roles, documents and data types. Progress is easier to track. An audit trail of actions can be automatically created.

There's frequently confusion between "processes" and "workflows" when discussing PLM. A business process is an organised set of high-level activities, with clearly defined inputs and outputs, that creates business value. A workflow is the automation of a few low-level tasks. Although a workflow only contains a few tasks, it can be difficult to implement without running into pitfalls (Fig. 3.22).

ensure the required activities are executed	improve effectiveness
improve coordination between workflow participants	reduce costs
on demand, provide task details to participants	support initiatives to comply with regulations
enable the participation of a broader range of functions	take advantage of new technologies

Fig. 3.21 Some benefits of workflows

poor user interface	no intelligence - automates process errors
missing workflow functionality	limited workflow version management functionality
unable to assign tasks to roles	overload of unimportant and irrelevant notifications
no link to the company's e-mail system	small variations in the tasks aren't handled

Fig. 3.22 Potential pitfalls with workflows

average cost of changes	percentage of approved changes not implemented
average cost ($) for a Fast Track change	average time (days) taken to approve an ECR
number of changes per product family	average time to execute the process

Fig. 3.23 Some KPIs for business processes

3.2.7 KPIs for Business Processes

A Key Performance Indicator (KPI), or metric, is a quantifiable attribute of an entity or activity that helps describe its performance (Fig. 3.23). It's something that can be measured to help manage and improve the activity.

KPIs help a company to set targets for its business processes and to measure the progress that it's making. For each metric there's a current value and there can be target values for the future.

3.2.8 The Importance of Business Processes in PLM

3.2.8.1 A Company Is Its Processes

Business processes are "what a company does". Processes are important. The company has a choice. It can put in place good processes, and do the right things well. Or it can do things badly. A lot of the processes in a company are product-related. In many companies, between 35 % and 55 % of the company's processes are product-related.

3.2.8.2 Revenues Result from Processes

The product is the source of company revenues. The product that the customer will eventually use is designed and manufactured by the activities of the business processes. This means that the quality and cost of the product are functions of the processes. And, the elapsed time between the first idea for a product, and the moment that the first customer receives the product, depends on the efficiency and effectiveness of the processes.

3.2.8.3 Waste Results from Processes

Disjunctures, superfluous steps, and inefficient activities in business processes all contribute to unnecessarily extending lead times, increasing costs and reducing quality.

3.2.8.4 The Process Is What People Do

The activities and tasks that are executed by people fit into a business process. If you want people to work the "right" way, you need to define it in a business process. If you don't define how they should work, they may work the wrong way.

Examining the tasks in the processes reveals the skills that people will need. Once the required skills are known, hiring and training activities can be launched to develop these skills in the company.

3.2.8.5 Automation

Examining a process can result in seeing possibilities for applications and workflows to help people do the work.

3.2.8.6 Understanding and Improvement

Unless processes are understood, there's no way of improving them, no way of improving "how the company works".

3.2.8.7 Brother and Sister: Product Data and Business Process

The data that is input to business processes in the scope of PLM is product data (the subject of Chap. 4). The data that is output from business processes in the scope of PLM is product data. Without knowing the processes, the requirements of/from product data would not be known.

3.2.8.8 Process-Related Targets of a PLM Initiative

The targets of a PLM Initiative may be parameters of business processes. The objectives of a PLM Initiative may be related to the output of a process (e.g., number of new products per year). The objectives of a PLM Initiative may be related to a KPI of a process (e.g., Time to Market).

3.3 Process Reality in a Typical Company

3.3.1 Generic Issues with Business Processes

In a typical company, there will usually be many issues with processes in the PLM environment. The issues fall into several groups (Fig. 3.24).

Naming	Change, Version	Performance, Improvement
Purpose, Scope	Definition	Ownership, Training
Architecture, Structure	Value-adding, Lean	Representations, Model, Map

Fig. 3.24 Issues with business processes

3.3.1.1 Name and Scope

One of the issues is that there are no standard, "off-the-shelf" business processes. Each company has to develop its own processes. It chooses its own names for these processes, and fixes their scope. As a result, the many product-related activities and processes across the product lifecycle are given widely different names in different industries and different companies (Fig. 3.25).

A process may even be given several names in the same company. One person in the company may call a process Product Improvement, another may call it Product Upgrade. Others may call it the Modification process, or the Product Renewal process. This can lead to confusion. If people aren't sure about what they're doing, or should do, they won't work as effectively as possible. As all these people are from the same company, they are actually referring to the same process. When they work together, they work in the same process, whatever its name. However, sometimes they may need to work with someone from a partner company. Then, for example, the person from the company who refers to this process as the Product Improvement Process may meet someone from the partner company who also refers to a process called the Product Improvement Process within their company. They may agree that they will work together, with one of the companies doing the first half of the process, and the other company doing the second half. This could lead to problems if this process has been defined differently in the two companies. In one company, for example, the process could include the collection of ideas generated by customers and by people in the company. In the second company, the idea collection activity could be in another business process, for example in the Idea Management process.

3.3.1.2 Development

It's not easy to develop effective but lean business processes. Unless a company invests a lot of time and effort, its processes may be poorly defined, and poorly documented.

Product Maintenance	Product Modification	Product Upgrade
Product Renewal	Product Support	Product Improvement

Fig. 3.25 Many similar names and scopes

Many processes are cross-functional. But it's often difficult, when developing a process, to get away from a departmental focus. A process developer from one department will tend to include everything needed by their department, and ignore the needs of other departments. They may add extra steps (and cost and time) to address a specific activity that interests them, even though it may rarely be needed in practice.

Process developers may focus on developing one process, and ignore its interactions with other processes. In the process that they are developing, they may include activities that are already in other processes. This can lead to redundant effort across the company.

To develop and document the process quickly, developers may use the words they are familiar with, their jargon. However, that will make it more difficult for other people to understand what's happening. And busy business process developers may not have time to define the purpose of the process clearly, or its scope, or even make sure that it has an owner.

3.3.1.3 Changes

As time passes, and the environment evolves, business processes will change, resulting in several versions of the same process. But there may be no version management system for processes. As a result, confusion may arise as some people start to work with a new version of the process, while others continue to work with the old version.

It's easy to forget, when developing processes, that the business environment is changing all the time, and processes will need to change. It's important to be flexible when working with business processes and process models. They need to be able to change to take account of these changes.

Without constant attention, business processes become increasingly slow and bureaucratic. There's always someone who wants to add in extra steps, "just to be sure". There's rarely anyone willing to take the risk of slimming the process down. There's always a danger of perhaps removing something that's really important. The result is that the processes take longer to execute than needed. They suffer from low quality, poor communications, a lack of management understanding, and a lack of structure.

3.3.1.4 Management

Unless business processes are managed, they will become less effective. Many issues may arise (Fig. 3.26). There may be several causes for these issues (Fig. 3.27).

Duplication or overlap of activities between different business processes may be unintentionally introduced. Process interfaces may be unclear, or overlap. Boundaries between processes may be unclear. Process ownership may not be clearly defined.

duplication of activities in a process	execution time too long
duplication of activities between processes	lack of visibility on the activities
gaps between processes	lack of visibility of progress
unclear roles and responsibilities	border issues between processes
activities that don't add value	incorrect performance reporting

Fig. 3.26 Typical issues with processes

too much time spent on mapping as-is	too few resources available to do the activities in the process
not enough time spent modelling to-be	activities added to the process without reviewing the impact
the process developers weren't trained	conflicting KPIs made people behave the wrong way
the process wasn't clearly defined	documentation out-of-date, people are too busy to update it
the process was badly automated	only Quality experts involved in process definition, not users

Fig. 3.27 Possible causes of the issues

As a result, perhaps nobody will feel responsible for monitoring or improving a process. Alternatively, perhaps several people will feel authorised to modify it.

There may be no metrics for some processes. In other cases, people may measure too much, or measure the wrong things. Or the same thing may be measured differently in different parts of the company. There may be no training about processes. Or training may not be sufficiently detailed or relevant. There may be no management commitment to ensure that processes are followed. There may be no management system to ensure that processes are continually improved.

3.3.2 Interaction with Other Activities

No business process is an island isolated from the rest of the company (Fig. 3.28). Every process is related to all the other PLM components. A change to a process can lead to changes in many other components. Business processes shouldn't be addressed independently of other components of the PLM environment.

For example, to improve performance, two business processes may be merged into one. In the future process, only one document may be needed instead of two.

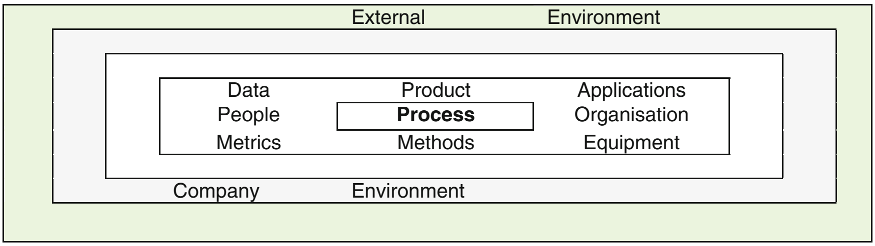


Fig. 3.28 No process is an island

The process documentation will need to be changed, and people will need to be trained on the new process and documents. The fields in the documents will be changed, and a new template developed. There will be changes to the application creating the document. There will be changes to the application managing the document. A performance indicator may need to be changed if it was previously based on an activity or entity in one of the two merged processes. The company's Quality Manual will be updated to show the new process.

In this example, a simple change to a process has affected four other components of PLM. More complex changes can have even wider impact.

3.3.3 Generic Issues with Methods

In a typical company, there will be many issues with business processes. There will also be many issues with the methods used in the PLM environment. Some of these are shown in Fig. 3.29.

Methods are used across the product lifecycle. Examples include Activity Based Costing (ABC), Concurrent Engineering, Design for Assembly (DFA), Design for Environment (DFE), Design for Recycling (DFR), Design for Six Sigma (DFSS), Design for Sustainability (DFS), Design to Cost (DTC), Early Manufacturing Involvement (EMI), Early Supplier Involvement, Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Group Technology (GT), Life Cycle Assessment (LCA), Life Cycle Design (LCD), Open Innovation, Plan-Do-Check-Act (PDCA), Poka Yoke (Mistake Proofing), Quality Function Deployment (QFD), Reliability Engineering, Roadmapping, Robust Engineering, Simultaneous Engineering, Stage/Gate methodologies, Taguchi techniques, TRIZ, Value Analysis (VA) and Value Engineering (VE).

Methods range from the very technical to broad-brush management approaches. The methods mentioned above have all met with success in one or more companies, and should be understood by companies embarking on PLM initiatives. However, all companies are in slightly different situations, so a method that is needed for one company may not be needed for another. A particular company may only need a few methods. Another company may be able to benefit from many. Selecting and prioritising such techniques and approaches is part of the activity of defining a strategy for PLM. One of the challenges of PLM for a particular company is to identify the methods that are most relevant to the activities on which the company wants to focus its efforts.

Naming	Evolution, Version	Relationship with IS
Definition, Purpose, Scope	METHODS	Relationship with processes
Duplication, Overlap	Implementation	Commitment

Fig. 3.29 Issues common to many methods

3.3.3.1 Unclear Name and Scope

The functionality of a method is often unclear from its name. Many umbrella terms such as Lean Production and Total Quality Management are used with a wide range of different meanings. Different proponents of a method may include different activities within apparently similar methods.

It's often unclear, from the name, exactly how one method differs from others. Some groups of methods, for example DFE, DFR and DFS, may appear to be similar, and may have overlapping activities.

3.3.3.2 Overlap Between Methods

There's often overlap between the objective, scope and activities of the methods mentioned above. It can be difficult, for example, to distinguish between Simultaneous Engineering and Concurrent Engineering. And the terms Value Analysis and Value Engineering are often used to refer to very similar activities.

3.3.3.3 Overlap Between Methods and Applications

Many methods are supported by related applications. Often these aren't integrated with other applications, and create new Islands of Automation.

3.3.3.4 Confusion Between Methods and Processes

People sometimes find it difficult to distinguish between processes and methods. A business process is an organised set of high-level activities, with clearly defined inputs and outputs, that creates business value. A business process will have to be defined in detail for each particular company. It has a well-defined input and starting point in the company. It has a well-defined output and end point in the company. Most likely it will be specific to the particular company. Methods are more general in nature. They aim to improve performance in a particular area in any company.

For every business process, there should be a document explaining the activities in the process, and how they should be carried out. Methods also define how activities such be carried out, so there is a possibility of overlap and contradiction.

3.3.3.5 Duplication of Existing Activities

Many methods duplicate, to some extent, existing activities. A technique such as Life Cycle Design is, of course important, but most companies will already have been doing product design for many years before embarking on Life Cycle Design.

They need to make sure that, if they apply Life Cycle Design, they only add new value-adding activities, or selectively improve existing activities, and remove any duplication that may arise.

3.3.3.6 Unclear Metrics

Without a clear definition or scope, it's difficult to know how to measure the impact of a particular method. Unless a lot of care is taken, any improvement that's claimed to result from one improvement method, could actually be due to another method or to external factors. For example, an improvement in Time to Market might be attributed to use of a phase-gate approach, but could actually result from outsourcing the development of product modules to suppliers.

3.3.3.7 Method Evolution and Confusion

After a method appears to achieve good results, its proponents will want to maintain the momentum. Conferences will be organised to explain the method. Its scope will be expanded so that those who benefited from the initial version can achieve further improvements. Confusion may result. Newcomers will be surprised to see there are two versions of the method. They will wonder if they should start with the initial version and achieve the benefits it offers, or start immediately with the second version.

3.3.3.8 Interaction of Methods with Other PLM Components

No method is an island. Methods are closely related to other PLM components. Changing a method is likely to result in changes for other components. For example, to improve performance, a company may decide to implement a new method. People will be sent to training courses to learn how to apply the method. They receive voluminous documentation, and details about various applications supporting use of the method. They visit other companies to see how the method can be applied, and to find out which application is best. Before the method can be used, some business process descriptions will need to be modified to take account of the method. Potentially affected people are trained about the new processes. An application is purchased to support use of the method. The data produced by the new application will need to be managed. A new interface will be needed with the company's PDM system. A new performance measure will be needed to measure the benefits of using the new method. What seemed like the simple addition of a method has ramifications across several PLM components.

3.3.4 Interaction with Company Initiatives

Company Initiatives address many subjects. Many of these will be far away from business processes in the PLM environment. However, some could have significant overlap. Examples include Business Process Management, Business Process Re-engineering, Concurrent Engineering, Innovation Management, Lean Engineering and Production, Lean Enterprise, Six Sigma and Total Quality Management.

Most companies have several initiatives running. Each of these has its own manager, is focused on its own process activities and success, and tends to see other initiatives as competitors. It's likely that the managers of some of these initiatives will see the PLM Initiative as a competitor for resources and for a successful outcome. To avoid problems in the PLM Initiative, it's useful to identify the other initiatives and find out which initiatives may be supportive of PLM and which will not. And then work out how to work effectively with all of them.

3.3.5 Generic Challenges with Business Processes

The specific process-related challenges that a particular company faces could be of various types (Fig. 3.30).

3.3.6 A Generic Vision for Business Processes in PLM

In a PLM Initiative, many companies will want to develop a PLM Vision, a view of their future PLM environment. Most companies work with Visions that are looking 5 years ahead. In my experience, these visions will be fairly similar, so a generic Vision can be very useful.

My experience with Visions started with a multi-client study that developed a common Vision for 20 companies. The initial idea came after a Corporate Vice-President of a Fortune 50 corporation asked me how much it would cost to develop a Vision of the future Engineering Environment. He told me that he was tired of his engineering managers implementing short-term uncoordinated improvement

product development process too slow	waiting for information to be reformatted
exact status of product upgrade projects not known	waiting for missing information to be created
engineering change process takes too long	lack of support for execution of processes
time lost in processes waiting for information	lack of knowledge about processes
superfluous tasks, adding no value, are carried out	duplication of processes
old processes that can now be executed better	overlap of a process with other processes
steps that are no longer required	steps in a process that create rework

Fig. 3.30 Potential process-related challenges for a company

projects that led to no measurable impact. He said he was looking for the Big Picture towards which all companies in his corporation could work over a 5-year period. My estimate of nearly $500,000 to develop the Vision seemed slightly too high for him, but the subject seemed a promising one. I turned to my friend Chris Horrocks, then of Coopers and Lybrand, Boston, to see if we could carry out a multi-client study on the subject. Eventually we found twenty companies willing to participate. Although they were in different industries and made all sorts of products (including soft drinks, rockets, helicopters, cameras, computers, cars, and trucks) our discussions with them were surprisingly similar. Obviously there were differences between different industries, particularly where there were strong regulatory forces, but there was more similarity than difference. The study took about 6 months to complete, after which we presented a common Vision.

With the Vision delivered, some of the participants asked what we would offer them next. They wanted to know how they could achieve the Vision. We proposed an Engineering Strategy multi-client study. This also had about 20 participants. Some of these had participated in the Engineering Vision study. Others, including a utility, hadn't. Whereas we'd found that it was possible to create a common Vision, we found it was more difficult to build a common Strategy. Although all the participants could aim for a common Vision, they were starting from different positions, and we had to take that into account. With the Strategy delivered, some of the participants asked what we would offer them next. Could we develop the Engineering Plan? Well, no. Whereas the Vision was common, and the Strategy had some commonality, we couldn't develop a common Plan as a multi-client effort. There wasn't enough commonality between the participants.

A complete PLM Vision addresses all of the components of the PLM Grid. Often the Vision for business processes will be described alongside that for another component, the product lifecycle. Some typical parts of a PLM Vision for business processes and the product lifecycle are described below, grouped in 10 main sections.

3.3.6.1 Phases of the Product Lifecycle

Our product lifecycle is defined as having five phases: imagination; definition; realisation; support; retirement. It's recognised that, for users of the product, there are also five phases in the product's lifecycle: imagination; definition; realisation; use (or operation); disposal (or recycling).

3.3.6.2 Management of the Product Lifecycle

The Product Lifecycle Owner has responsibility for defining and maintaining an effective product lifecycle, including the definition of the details of the lifecycle structure. There's a document describing the lifecycle structure.

3.3.6.3 Lifecycle Design and Analysis

Lifecycle design and analysis will play an increasing role in the lifecycles of our products. All issues related to a product's life will be considered at the outset, including those involving the product once its useful life is over. Lifecycle analysis will be carried out over the complete cradle-to-grave lifecycle including analysis of use of raw materials, production methods and usage/disposal patterns.

3.3.6.4 Lifecycle Modelling

The product lifecycle will be modelled and analysed to identify where most value can be added, and where waste can be reduced. Opportunities will be found in the early phases of the lifecycle to increase the speed of generating ideas, translating them into products, launching new products, and generating revenues and profits. Opportunities will be found in the mid-life phases of the lifecycle to ensure sales of a product are as high as possible, for example by extending the life of patents, and protecting the customer base against competitors. Opportunities will be found at the end-of-life phases of the lifecycle to increase sales with upgrades, or to exit the market graciously with product retirement, licensing or sale.

3.3.6.5 Process Definition and Automation

Clearly-defined, coherent, well-organised business processes across the product lifecycle lie at the heart of effective PLM. Our business processes will be waste-free and low-cost. They'll enable concurrent involvement by people in different functions and locations. They'll be well-documented. Otherwise it would be difficult for everyone to understand them. And it would be difficult to improve them further. The key roles in the processes will be identified and described, along with the corresponding task and information characteristics. People in many different companies working in different places round the world may take these roles. Hundreds of people may be directly involved in these tasks. The process needs to be explained to them, with regular refreshment. To avoid confusion, the message needs to be very clear.

A clear, standard business process architecture will enable coherent working across the product lifecycle. There's a document describing the business process architecture. A common harmonised version of each process in the product lifecycle will be used on all sites. Each process is documented.

Relationships between the business processes in each phase of the product lifecycle will be defined. Relationships between the processes in different phases of the product lifecycle will be defined. Relationships between processes in the area of Product Lifecycle Management, and those in other areas such as Supply Chain Management and Customer Relationship Management, will be defined. When possible, process steps will be automated in workflows. The workflows will be consistent with the process definitions. When possible, appropriate methodologies and working techniques will be defined for each process step.

3.3.6.6 Standard Lifecycle Processes

The company will define standard business processes, standard product data and standard PLM applications. The company, and its suppliers, customers, and partners in the extended enterprise, will use them to save time and money. Without such standards, each interface between different processes and applications would be a source of chaos, would add costs, and would slow down the lifecycle activities.

3.3.6.7 Standard Lifecycle Methodologies

Without a standard product development and support methodology, it's unlikely that people are going to be able to work in harmony across the lifecycle. A well-defined methodology lets everybody know exactly what's happening at all times, and tells them what they should be doing. It defines the major lifecycle phases and explains what has to be done in each phase. It shows how the phases fit with the company organisation and structure. It shows the objectives and deliverables at the end of each phase, and the way that phases connect together. It shows which business processes, applications and methods apply at which time in each phase. It shows the human resources that are needed, identifying the type of people, skills, knowledge, and organisation. It shows the role and responsibilities of each individual and the role of teams. It shows the role of management, project managers, functional reviewers and approvers. It describes the major management milestones and commitments. It describes the metrics used in the business processes.

3.3.6.8 Mandatory Compliance

PLM supports our activities to meet mandatory compliance requirements of international and industry regulations in areas such as health, safety and environment. It helps maintain documentation in required formats, and provides an audit trail showing actions taken. There's a document describing the compliance requirements.

3.3.6.9 Voluntary Conformity

PLM allows the company to do more than just comply with regulations and laws. It allows us to go further, and demonstrate our beliefs in the importance of the environment, social justice, health, education and sustainable development. PLM enables voluntary compliance with recommended practices and guidelines in these areas. PLM enables us to act responsibly and address the effect of policies for sustainable production and consumption of existing and new products. Voluntary conformity can improve financial performance. Sustainable development and environmental needs represent major business opportunities for faster growth and profitability through improved current products and services, and innovation of new products and services. PLM lets us take advantage of voluntary self-regulation initiatives and use them to build new markets.

3.3.6.10 Progress with Lifecycle and Process

Targets are needed to measure the success of PLM deployment. The "report" in Fig. 3.31 might be written 5 years after the PLM Initiative is started.

3.4 Business Process Activities in the PLM Initiative

A PLM Initiative takes a company from its current PLM situation to a desired future PLM situation (Fig. 3.32).

3.4.1 Projects Related to Business Processes

In most PLM Initiatives, there are many projects addressing business processes. Some examples are shown in Fig. 3.33. Depending on the Initiative, some of these projects may run independently. Some may run in parallel, or overlap. Others may be linked to Initiative projects related to product data, PLM applications and/or change management.

Projects addressing business processes are usually cross-functional and include people from across the product lifecycle. However, people coming from different backgrounds may have very different understandings of the terms used in the

The lifecycle architecture was defined and applied. A lifecycle-wide business process architecture has been defined and applied. The number of different, site-specific, variants of what should be the same business process has been reduced by 50%. The target is to implement a common harmonised version of each process in the product lifecycle across all sites. There's a common harmonised Engineering Change Management process.

The number of process steps that has been automated in workflows has been increased by a factor of four. There's still a long way to go. Initially, different sites had very different business processes and applications. A lot of harmonisation was needed before it made sense to introduce automated workflows. After reviewing quality problems, feedback processes were defined and introduced to ensure effective feedback of information from product users to product developers. Business processes have been reviewed and upgraded with activity steps that ensure and demonstrate compliance with regulations.

Fig. 3.31 Reporting progress with business processes and the product lifecycle

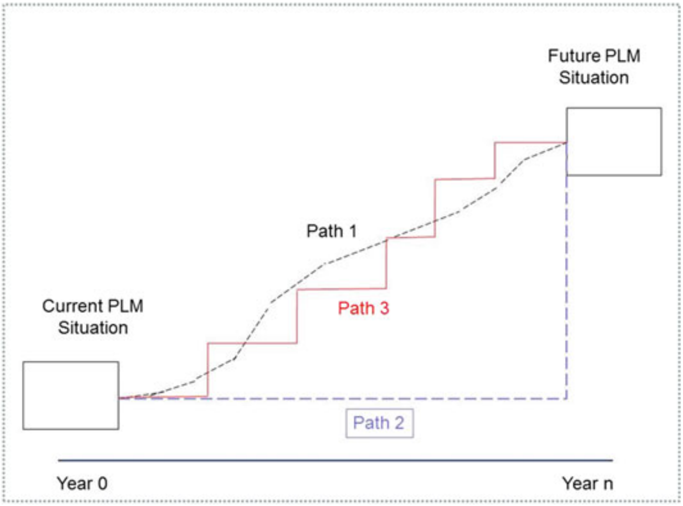


Fig. 3.32 Current and future PLM situations

plan activities related to business processes	map the current process
develop the business process architecture	model the future process
develop the business process strategy	coach Process Owners
improve business processes	define process KPIs
develop a Process Glossary	define Use Cases
provide Business Process training	create Workflows

Fig. 3.33 Examples of projects related to business processes

business process environment. So it's helpful to develop a glossary that gives short definitions of the various terms used in business process management. This will help everyone to understand the terms being used. It should lead to a common understanding of the subjects to be addressed.

Similarly, some of the people in the project may know little about business processes. Many of the members of the team may never have participated in activities addressing business processes. It may be difficult for them to know how best to plan their activities and go about their work. As a result, some training about business processes and business process improvement will be useful.

3.4.2 Business Process Improvement

There are many reasons why a company may have started a project to improve a business process, or want to start such a project. As a result, there may be several targets for process improvement (Fig. 3.34).

reduce costs of process execution	streamline the process
ensure conformance to regulations	reduce process execution time
improve visibility into processes	reduce waiting time
increase control over key processes	remove bottlenecks
improve the quality of a process	remove multiple sign-offs
improve the quality of input data	increase parallelisation of activities
harmonise processes across sites	apply a common change process

Fig. 3.34 Targets for business process improvement

Without constant attention, business processes become slow and bureaucratic. For various reasons, extra tasks and documents are included, just to be sure. And, as the business changes, other additions are made to the process, leading to duplication or overlap of activities with other processes. As time passes, and the environment evolves, yet more new tasks are added to handle the new situation. Extra tasks are added to reduce problem areas in the process. The end result is that the process takes longer to execute than it should.

Projects to improve business processes may run as part of a PLM Initiative or independently. In either case, they are likely to be challenging. Many people work in the business processes. Any changes are likely to upset some of them. Some success factors for projects to improve business processes are shown in Fig. 3.35.

3.4.3 Business Process Mapping and Modelling

In most PLM Initiatives there will be a project to model the business processes. Business process mapping and modelling can be carried out for many reasons (Fig. 3.36). However, there is often similarity between modelling projects in one

take a structured approach to process improvement	involve management
focus on adding value for the company's products	involve lifecycle participants
prepare to manage organisational change	provide training and coaching
get and maintain management commitment	select a process champion
measure process performance	map the existing processes
benchmark with companies with similar processes	model the future process
define the business objective	demonstrate expected business benefits
define the business process before buying software	reward, reinforce, continuously improve
hire experienced Subject Matter Experts as consultants	be patient

Fig. 3.35 Success factors for business process improvement

to define a business process	to clarify the documents used in the process
to document a process	to keep pace with the changing world
to improve a business process	as a basis for software selection
to make a process compliant	to lay the ground for workflows

Fig. 3.36 Some reasons for business process mapping

company and those in other companies. For example, there may be a similar need to document processes. Similar process mapping tools may be used. Similar business processes may be addressed. Similar performance improvements may be targeted. Similar automated workflows may be possible.

Due to the similarities, it's possible, from experience, to identify some guidelines for business process mapping and modelling (Fig. 3.37).

A business process map is a very good basis for getting everyone to understand the process being addressed. It's also an excellent starting point for improving a process. And there are many other advantages to mapping business processes (Fig. 3.38).

Often it's not necessary to start the mapping activity from scratch. Many companies will have already defined their business process architecture. Process maps will be available. They can be a good starting point for further documenting the processes. Sometimes a company will have carried out value stream mapping. Value stream maps can also be a good starting point for documenting business processes.

3.4.4 The ECM Business Process

The Engineering Change Management (ECM) process is a good example of a business process in the PLM environment. All companies have this business process. It allows a product to be changed in a controlled way. Whatever its name in a particular company, it's very likely that it will be addressed in the PLM Initiative. So it's useful to know something about it.

define the business process to be mapped	define which symbols will be used
define the objectives and owner of the process	define the mapping/modelling team, involving users
define the scope and boundaries of the process	identify any training needs for process mapping training
define the triggers at the beginning of the process	carry out training as required
define the outputs at the end of the process	carry out the actual process mapping/modelling activity
define the roles in the process	keep copies of all documents used in the process
define the levels of the process that will be mapped	review and revise the maps/models

Fig. 3.37 Guidelines for process mapping and modelling

a process map is a good sharable documented description of a process
process maps are good communication tools
a process map is easy to understand
a process map allows improvement opportunities to be positioned
process mapping allows many people working in the process to be involved
process mapping can be adapted to different circumstances
process maps can be used for training
process maps can be used to meet compliance requirements

Fig. 3.38 Advantages of process mapping

3.4.4.1 Process Name(s)

Like most business processes in the PLM environment, the Engineering Change Management process comes with its own jargon and acronyms. Among the most frequently encountered are: Engineering Change (EC); Engineering Change Board (ECB); Engineering Change Committee (ECC); Engineering Change Control (ECC); Engineering Change Management (ECM); Engineering Change Notification (ECN); Engineering Change Notice (ECN); Engineering Change Order (ECO); Engineering Change Proposal (ECP); Engineering Change Package (ECP); Engineering Change Request (ECR).

This process has different names in different companies (Fig. 3.39). Some people prefer to refer to it as the Product Change process rather than the Engineering Change process. That leads to another 10 names and acronyms. Others refer to it as the Document Change process rather than the Engineering Change process. That leads to another 10 names and acronyms. Other people call it the Enterprise Change process. And some refer to it as the Electronic Change process. The two latter options lead to additional confusion as the acronym EC can then refer to Engineering Change, Enterprise Change or Electronic Change.

3.4.4.2 No Standard Process

It would be great if there was an internationally standard ECM process that a company could use. Unfortunately this doesn't exist. Each company has to "roll its own". However, they can look for guidance in documents such as:

- ISO 9001:2008, "Quality management systems—Requirements"
- ISO 10007, "Quality management systems—Guidelines for configuration management"

Section 7.3.7 of ISO 9001 addresses "Control of design and development changes". It states, "Design and development changes shall be identified and records maintained. The changes shall be reviewed, verified and validated, as appropriate, and approved before implementation. The review of design and development changes shall include evaluation of the effect of the changes on constituent parts and product already delivered. Records of the results of the review of changes and any necessary actions shall be maintained."

Section 5.4.1 of ISO 10007 addresses Change control. It begins with "After the initial release of product configuration information, all changes should be controlled. The potential impact of a change, customer requirements and the

Change Management	Engineering Change Management	Change Control
Product Change Management	Document Change Management	Product Change

Fig. 3.39 Similar names for the process

configuration baseline will affect the degree of control needed to process a proposed change or concession. The process for controlling the change should be documented, and should include the following".

3.4.4.3 Purpose

The purpose of the ECM process is clear. Whenever a company creates a product, that product has to be defined. And its definition will need to be kept up-to-date as changes take place. In some environments, such as high-tech environments, where initial product designs are often continuously evolving prototypes, changes to a product can occur frequently. They also occur in other environments due to technological changes, changes in consumer demand, and fluctuations in the availability of components and raw materials. Engineering Change Management ensures that changes are clearly defined, documented and controlled throughout the product lifecycle.

The company's products and processes, and their descriptions, are the main focus of Engineering Changes. In most companies, there are many products, main assemblies, sub-assemblies, components, parts, raw materials, processes and sub-processes, product data and documents, process data and documents. And every day, some of them need to be changed. There's a lot to keep under control.

3.4.4.4 Objective

The ECM process provides an orderly approach for evolving the definition of a product. It provides flexibility without compromising careful control of the manufacturing process. It ensures that product evolution occurs smoothly and with proper authorisation. ECRs and ECOs allow changes to be managed efficiently without interrupting production of existing products. Engineering Changes allow product and process information such as models, drawings, BOMs and NC programs to be updated and activated according to a clearly-defined and agreed schedule.

Effective Engineering Change Management eliminates problems that could arise from people not using the latest version of a document. Getting everyone to follow a formal change procedure eliminates problems caused by unauthorised changes to documents. It reduces risk by ensuring that the appropriate people know of changes, and receive up-to-date and complete information. It gives full traceability of all documentation and relationships.

3.4.4.5 Need for Change

Everybody needs good Engineering Change Management. Everyone wants the current version of data. Order Processing requires accurate versions of product data and release status. Planners need to phase out old versions while phasing in new releases. Development engineers need to know how to meld their changes with other changes to maintain consistent designs. Manufacturing needs accurate and timely information about all changes past, present and planned. Customer Service has to communicate product improvements to customers.

3.4.4.6 Sources and Reasons for Change

There are many potential sources and reasons for Engineering Changes (Fig. 3.40).

But it's not easy to manage changes (Fig. 3.41).

3.4.4.7 The Risk of Uncontrolled Change

In theory, Engineering Change Management keeps everything under control. But, in practice, unless the process works perfectly, problems will arise. A market window may be missed because a communication error in the Engineering Change process delayed the product. When ECOs are hand-written and distributed by hand, it can be difficult to read them, and sometimes they just get lost. If there are long loops in the process, they create problems with dates, costs and quality every time they cross an organisational interface. Several different information sources, including paper, may have to be accessed to gather the necessary information for the analysis. This can make the whole EC process time-consuming and error-prone. Changing a Bill of Materials can be the worst, because it's so difficult to represent the changes in an accurate, consistent way. If much of the information has to be entered manually in the ECR from upstream applications, and entered manually from the ECO into downstream systems, many errors and problems can be introduced. All sorts of errors can get into the ERP database, leading to production delays, wrong products, scrap and lots of inventory. If a small change to a product specification is overlooked, and doesn't make it into a new revision of a drawing,

Change Source	*Potential Reason for Change*
Customers	have problems with existing products, and have new requirements
Design Engineers	always want to improve functionality
Software Engineers	always need to fix bugs
Purchasing Department	always wants to use new suppliers with better offerings
Standardisation Group	wants to reduce the number of parts used in the company's products
Marketing and Sales	always want many new and modified products
Production	always wants to improve its machines and their utilisation
Suppliers	always propose changes to the way they contribute
Installation Engineers	always give input on what is really important in the Field
Customer Service	collects application problems and expects quick fixes
Manufacturing Engineers	always want to reduce costs
Regulatory Authorities	always change their rules

Fig. 3.40 Examples of Engineering Change sources and reasons

It's not easy . . . .
to make changes, yet be sure everyone is working with the latest set of documents
to allow changes to occur, yet be sure the information is up-to-date and easy to find
to keep a geographically dispersed team up-to-date with changing specifications
to inform off-site team members instantly of changes
to manage changes to off-line and paper documents
to do change-impact analysis as far down as tooling and manufacturing process costs
to link changes to databases for instant updating
to drive down review and approval cycle times
to monitor change approval and implementation progress
to know the exact status of all change orders
to minimise change cycle time, cost and effort
to track a large volume of changes
to manage and control product revisions
to manage 'as designed' versus 'as changed'
to find out about planned changes when previous changes are still pending
with so many changes, and changes to changes, to find the history of past changes

Fig. 3.41 Some reasons why it's difficult to manage Engineering Changes

the error may not be found until after the first batch has been delivered. A poor engineering change process can lead to customer dissatisfaction, production inefficiency and higher production costs.

3.4.4.8 The Danger

The result of the problems that can result from a poor ECM process is a lot of unhappy people (Fig. 3.42). Innovation and new product development activities suffer. Time is wasted, time runs out. Costs go up. Quality goes down. Changes are seen as a nuisance and an interference that can lead to internal confusion, product recalls and even worse, product liability actions.

3.4.4.9 The Future

Market trends are leading to Engineering Change Management becoming even more necessary in the future. More locations will be involved. More people will be involved. Key customers will request more and quicker changes to products.

customers	unhappy because they received the wrong product, or a wrong release of it, or the wrong replacement part, or because of late delivery, especially when new products are launched
managers	unhappy with budget overrun, schedule overrun, lack of visibility of changes, and unintended side effects
product developers	unhappy to be overloaded with changes that use up most of their energy, and prevent them developing great new products

Fig. 3.42 Some people who may be unhappy with poorly organised ECM

As a result, it's important to get the ECM process working as well as possible. The results of an effective and efficient process will be numerous. Customer satisfaction will increase as customers see their requests turned into new and improved products. Managers will have more time available for value-adding activities. Product developers will be able to focus on innovation of new products. Cost reductions will become effective sooner. Quality improvements will become effective sooner. Time savings will allow everyone in the company to focus on what's really important.

3.4.4.10 Typical Activities

Due to the differences between companies, it's unlikely that any two companies will have exactly the same ECM process. However some of the tasks that make up the process may be similar (Fig. 3.43).

3.4.4.11 Different Numbers of Steps

A small company with a few people making simple $10 fashion products doesn't need the same change process as a company making $250 M aircraft that are expected to fly for 50 years. The ECM needs of different companies are very different. As a result, companies carry out the Engineering Change activity in many different ways, and with different numbers of steps. In the following examples, the number of steps ranges from 3 to 19.

In some companies, the following three steps may be enough:

- Step 1. Draw a line through the old information, write in the new information, date and sign
- Step 2. Record the effective date for the change in the Change Book
- Step 3. On the effective date, remove the old documents from Production, and replace them with the modified documents

create a change request, detailing items to be changed, and affected items
detail the change request with a description, reason and change category
receive change requests every day from many sources
screen the requests, and filter symptoms from root causes
evaluate the requests and the consequences of the change
decide what to do
request the selected changes to be made by various functions
carry out the changes
track the changes through the process
document all activities and the resulting consequences
notify the changes
manage the change process
report change process metrics

Fig. 3.43 Typical tasks in an ECM process

In another company, the following nine steps might be needed: Prepare Change Proposal; Approve Change Proposal; Authorise Impact Analysis; Prepare Impact Analysis; Authorise Change Order; Prepare Change Order; Perform Sign-offs; Approve Change Order; Notify Change Order.

Another company might have 21 steps (Fig. 3.44).

Several conclusions can be drawn from the above examples. Firstly, the process followed in different companies can be very different. Secondly, a list of process steps is not very clear. Thirdly, the terminology (e.g., the meaning of ECO) is not clear. Fourthly, the alternative actions at decision points are unclear. Fifthly, the content of the forms (e.g., the ECR form) is not defined.

A process map (Fig. 3.45) can be much more informative than a list of process steps.

The map gives a better understanding of the process. However some information is still missing. For example, a process map doesn't show the fields in the Problem Report, ECR and ECN documents. The process map doesn't show what type of problems may take a Fast Track and which must follow the Full Track.

The process map doesn't show the conditions under which this process is to be applied. For example, some companies apply this process from the initial creation of an artifact (e.g. a document), while others only apply it after initial release of the artifact.

The process map doesn't show the artifact that's the subject of the change. Some companies will show an artifact on the map, while other companies will show a link to another process where the artifact is changed.

A process map gives a good overview, but not a complete description of the process. A process will be used by a lot of people in a company. It needs to be clear to all of them. A Process Description Document (Fig. 3.14) is required to make everything crystal clear.

3.4.5 The NPD Business Process

Another process that's likely to be addressed in the PLM Initiative is the New Product Development (NPD) process. This is the process that gets a new product to market. It's good to know something about it, before trying to improve it.

1	fill in the ECR form	12	investigate impact
2	send the ECR to the Technical Services Department	13	schedule ECB Meeting with EC Chair
3	assign a number to the ECR	14	review all aspects of the ECR
4	send the ECR to the appropriate department	15	agree effective date
5	review problem, identify causes, evaluate solutions,	16	sign the ECR
6	propose effective date	17	send ECO to Technical Doc. Group
7	send ECR to the Technical Documentation Group	18	update documentation
8	ensure latest revision of all documentation is available	19	make copies
9	make an ECR package	20	distribute copies
10	send a copy of the ECR package to each ECB Member	21	file ECO
11	review the proposed change		

Fig. 3.44 21 steps in an ECM process

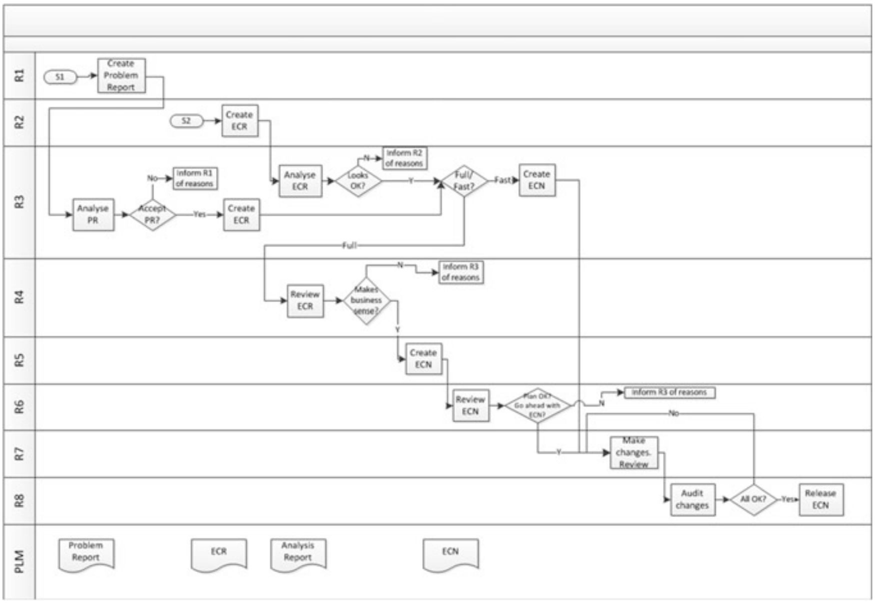


Fig. 3.45 ECM process map

3.4.5.1 Process Name(s)

Like most business processes in the PLM environment, the NPD process has its own jargon and acronyms. There isn't a standard name for the process, there are several alternative names (Fig. 3.46).

3.4.5.2 No Standard Process

Just as there isn't a standard name for this process, there isn't a standard content. It would be great if there was an internationally standard NPD process that a company could use. Unfortunately this doesn't exist. Each company has to "roll its own". However, it can look for guidance in documents such as:

- ISO 9001:2008, "Quality management systems—Requirements"
- ISO 13485:2003, "Medical devices—Quality management systems—Requirements for regulatory purposes"

New Product Development	Product Innovation	New Product Idea	Product Creation
New Product Commercialisation	New Product Introduction	Product Realisation	New Product

Fig. 3.46 Different names for the process

determine product requirements	control development changes	plan service provision
review product requirements	purchasing	prepare for labelling
design	control nonconforming product	prepare for packaging
development planning	risk management	monitoring and measurement
development review	customer communication	use of equipment
development verification	corrective and preventive action	inspection
development validation	prepare manufacturing tools	testing
design planning	plan production	verify purchased product

Fig. 3.47 Possible activities in this process

- CFR—Code of Federal Regulations Title 21 Food and Drugs…. Part 820 Quality System Regulation

From these documents it will see some of the activities that it may need to include in the process (Fig. 3.47).

3.4.5.3 Stage and Gate

Many companies use some form of stage and gate approach to NPD along the lines described in Robert Cooper's "Winning at New Products". This approach offers many benefits (Fig. 3.48).

However, just as companies may use many different names for the same process, they may use different names for Stages (Fig. 3.49).

Companies may also have different names for Gates (Fig. 3.50).

And sometimes, instead of a Gate they may use a Control Point or Check Point (Fig. 3.51).

Each company that we have worked with has had a slightly different stage and gate approach. However, the underlying principle is always the same.

In the preparation phase of a stage and gate approach, the first thing that happens is that the company defines which activities occur in each stage of a project. Sometimes, the same definition is used for all projects, sometimes there are different definitions for different types of project, for example, for large, medium and small projects. Each activity is broken down into its constituent tasks (Fig. 3.52). Each task is detailed to show who should do it, what methods they should use, and the deliverables resulting from the task. Then the tasks are arranged in the order in which they should be carried out. The gates are then positioned. The profiles of the

a best practice, template-based approach for all projects
all the activities and roles in a project are clearly defined
projects are structured in several stages, not one huge chunk
project information is progressively detailed and reviewed in each stage
at each gate, management reviews the project (thus stays involved)
at each gate, poor performers are stopped if they fail pre-defined criteria
project portfolio reporting is simplified as all projects have the same structure

Fig. 3.48 Some benefits of a stage and gate approach

Stage						
1		Assess	Scope	Explore	Business Review	Requirements
2		Define	Business Case	Appraise	Concept Design	Design
3		Develop	Develop	Develop	Develop	Implement
4		Validate	Test	Produce	Prototype	Verify
5		Commercialise	Market Launch	Deliver	Product Launch	Launch

Fig. 3.49 Different names for stages

Gate 0	Project launch decision	
Gate 1	Market/product screening decision	Screening
Gate 2	Concept/business case decision	Business Case
Gate 3	Development complete decision	Production
Gate 4	Product launch decision	Pre-Commercialisation

Fig. 3.50 Different names for gates

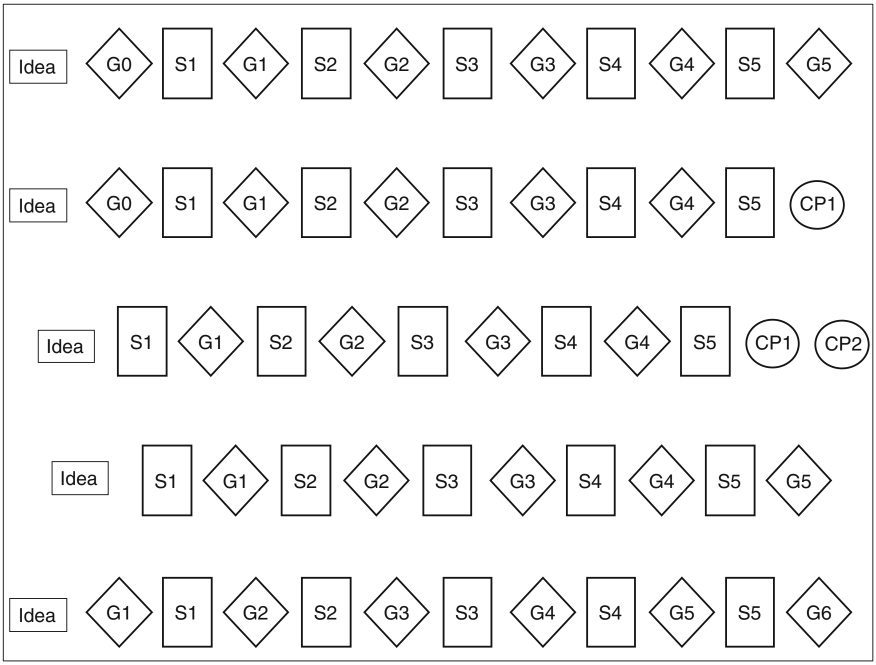


Fig. 3.51 Different structures of stages, gates and control points

required Gatekeepers at each gate are described. The gate criteria are defined. These often include criteria such as likely revenues, expected costs, expected time frame and launch date. For example, it may be decided that a certain type of project will

Fig. 3.52 Possible tasks in activities

define market segments	carry out design review
identify competitors	estimate manufacturing cost
identify competitive products	select production site
develop promotion materials	identify potential suppliers
identify concepts	perform make-buy analysis
investigate concept feasibility	design tooling

only be allowed to pass Gate 1 if expected revenues are greater than $100,000, costs are less than $50,000 and time to project completion is less than 6 months.

In the execution phase, a project is started after a management review of the project proposal at Gate 0. (The Gate 0 Gatekeepers decide, using the pre-defined criteria, whether the project proposal should: proceed to Stage 1, be put on hold, be rejected.)

The work in Stage 1 is carried out. At Gate 1, the Stage 1 deliverables are reviewed by management Gatekeepers to decide whether the project should: proceed to Stage 2; rework part or all of Stage 1; be put on hold; or be stopped. The decision is taken using the pre-defined criteria.

3.4.5.4 Lessons Learned

A stage and gate approach supported by a PDM system often satisfies the requirements of several types of user. Managers get a clear overview of project progress, while product developers are supported as they work with the details of their everyday tasks. From the user point of view, the environment appears to be focused on the particular project that they are working on. They can immediately go into the Stage of the project that they're working on, and see the current progress, on-going tasks and data requirements. They also see the contributions of other members of the project team, who may be from other functions or based on another site. Template documents are available to help users. They can be guided to use particular techniques (such as FMEA, QFD and risk management) at relevant times. The stage and gate capabilities allow senior management to take an active and influential role in determining project validity and continuation, using these capabilities as a go/no-go decision-making tool at each gate.

3.4.6 The Portfolio Management Process

In some PLM Initiatives, there'll be a sub-project to address Portfolio Management. Because PLM aims to maximise the value of the portfolio, management of the portfolio is one of the most important activities in PLM. From experience, most people in a PLM Initiative know little about this process, so an introduction is useful.

3.4.6.1 Different Scopes

There is often confusion with this process because it has two main components, and these are frequently addressed separately.

One of these components is management of the Portfolio and Pipeline of New Product Development projects. This includes the activity of sequencing the set of product opportunities available to a company for investment. It identifies the sequence in which the corresponding product development, improvement and phase-out projects should be carried out to provide most value. A typical output from this component is a report showing the cumulative cost and value of development projects (Fig. 3.53).

Another output is a Bubble Chart (Fig. 3.54) of projects from different product lines showing the likelihood of success, the expected Net Present Value (NPV), and the resource cost.

The other component of the Portfolio Management process is management of the portfolio of existing products. This includes activities such as tracking the increasing sales of high-performing products, understanding the return on specific products and groups of products, and identifying underperforming products. A typical output of this component shows the planned age distribution of products over time (Fig. 3.55).

Both of these components address a company's products. One addresses planned products, the other addresses existing products. There's a lot of interaction between them. For example, in a project to develop a new product it's important to know if it

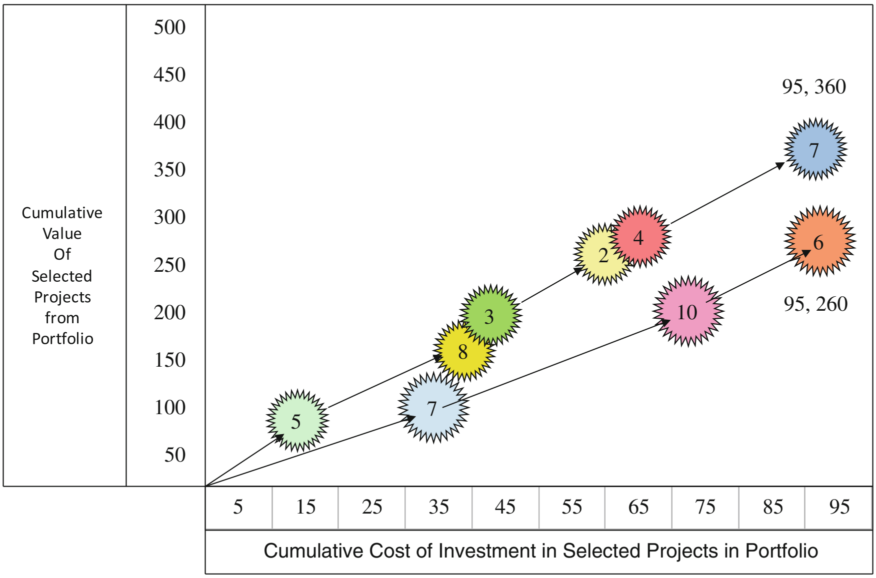


Fig. 3.53 Cumulative cost (x) and value (y) of projects

Fig. 3.54 Likelihood of success (x), NPV (y), resource cost (bubble size)

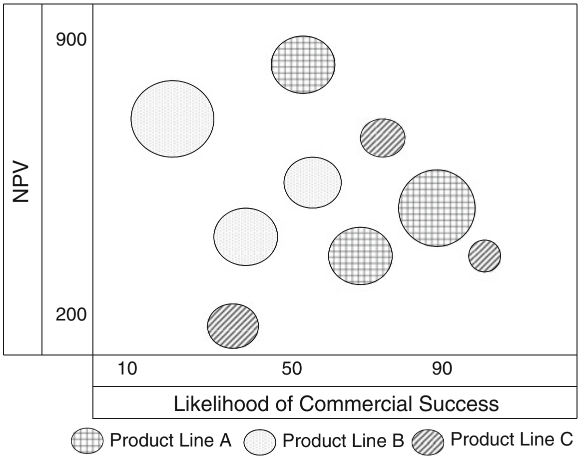
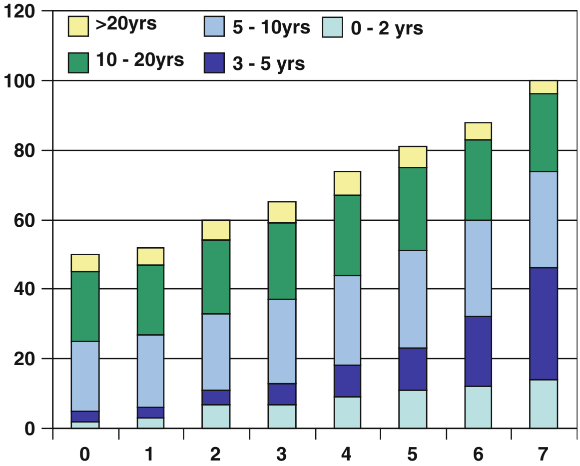


Fig. 3.55 Planned age of products over the next 7 years



will cannibalise sales of an existing product. However, before the emergence of PLM, the two components were often treated separately, perhaps because they were assigned to different departments.

3.4.6.2 Process Name(s)

With two components, it's not surprising that there are several names in use for this/these process(es). They include Portfolio Management, Project Portfolio Management, Product Portfolio Management, Program Portfolio Management, R&D Portfolio Management, NPD Project Portfolio Management, Integrated Product Portfolio Management and Integrated Portfolio Management.

3.4.6.3 NPD Project Portfolio Management

Many companies have hundreds or even thousands of new product development projects running or planned. They want to be sure that their product development resources are focused on the best set of projects. Another objective is to be able to compare quantitatively the value of each project in the portfolio, so that decision-makers have clear visibility of the situation and can make informed decisions.

Participants in a Portfolio Management process, such as Portfolio Managers and Product Managers, usually have a very clear idea of what they want to achieve (Fig. 3.56). For example, they want Portfolio Management to help them derive new product strategies, enhance traditional risk/return calculations, and visualise the result and return of different product-related projects. In global markets with, on one hand, vendor consolidation, and on the other hand, many start-ups, they see things changing fast. They know what reports they need, and they expect portfolio reviews at least every month to keep up-to-date with the situation.

3.4.6.4 Similar Starting Point

There are many reasons (Fig. 3.57) why a company may want to improve portfolio management. There may be a need to improve the overall return on the investment in product development and improvement projects. There may be too many projects relative to the available resources. As a result, projects are staffed with fractional resources. There may be a lack of consistency between the evaluation methods used to value different projects. Different managers may develop and use different types of business cases, making it difficult to compare different projects and to identify the relative priorities of projects.

make informed decisions	enhance traditional risk/return calculations
maximise portfolio value	know the best set of projects has been selected
reduce project cycle times by 45%	increase successful project completion rates by 30%
help derive new product strategies	be sure projects are aligned with business objectives
have clear visibility of the situation	focus product development resources on the best set of projects
sequence potential product opportunities	visualise results/returns of different product-related projects
review the portfolio at least once a month	compare quantitatively the value of each project in the portfolio

Fig. 3.56 Some objectives of Project Portfolio Management

difficult to compare different projects	different managers using different types of business cases
product development times of many years	lack of consistency between methods used to value projects
corporate objectives demand more for less	projects eating resources that would be better used elsewhere
too many projects relative to available resources	product developers keeping projects alive after their kill date
need to improve product development project ROI	about half the projects cancelled before commercialisation
difficult to identify relative priorities of projects	developers not focused on projects creating business value

Fig. 3.57 Reasons for introducing Project Portfolio Management

3.4.6.5 Requirement

To improve the situation, a company may start a project to define, implement and use a Portfolio Management process for all projects in the Portfolio. Selection and use of a related application to support the process is often targeted.

Among the requirements for the Portfolio Management process (Fig. 3.58) may be a need to track the value of the overall portfolio and of individual projects. Another can be to enable understanding of the upper and lower limits of a project's value. This implies understanding the variables that can lead to different values. Another requirement for the process can be a feedback loop to address non-conformance and to derive more benefits in the future from real-life experience. Other requirements include support for performance metrics. These include the Net Present Value (NPV) of projects launched during a particular time period, cycle time, and the number of projects for which premature termination occurred.

Another requirement can be the use of templates to provide a standard basis for understanding, evaluating and comparing projects.

3.4.6.6 Reports

Often, there's a requirement for the output of standard reports (Fig. 3.59) that give executives information such as the degree of portfolio alignment with strategic targets, the expected portfolio return, the mix of short-, medium-, and long-term projects, project risk versus reward, and the mix of risk across all projects in the portfolio.

provide support for KPIs	understand the upper and lower limits of a project's value
track the value of individual projects	derive more benefit in the future from real-life experience
track the value of the overall portfolio	encourage identification/understanding of project risks
add a feedback loop to address non-conformance	create standard reports giving executives useful information
include tasks to give praise for good performance	use templates as standard basis to compare projects
include tasks with ways to learn from problems	include decision criteria rules to "continue/kill projects"

Fig. 3.58 Requirements for the Project Portfolio Management process

project risk vs reward	mix of short-, medium-, and long-term projects
expected portfolio return	expected age of products over the coming years
planned source of future products	mix of risk across all projects in the portfolio
planned future of current products	degree of portfolio alignment with strategic targets
cumulative cost and value of projects	likelihood of project success compared to its NPV
planned completions per calendar year	customer view of project innovation vs internal view of risk

Fig. 3.59 Typical reports for Project Portfolio Management

all projects must be categorised	need for enterprise-wide involvement
the process must be driven by business strategy	a top manager should own the process
all projects should be in the same portfolio	standard templates should be used wherever possible
the process must fit with other company processes	processes to create high-quality data may not exist
key characteristics of projects must be identified	KPIs are needed to track portfolio and project progress
all projects must have the same characteristics	good portfolio decisions are based on high-quality data
need for management involvement and agreement	a new process can lead to organisational changes
without high-quality data, the results will be poor	old processes and applications should be removed

Fig. 3.60 Lessons learned from implementing Portfolio Management processes

3.4.6.7 Lessons Learned

Many lessons can be learned when implementing a Portfolio Management process (Fig. 3.60). Good Portfolio Management requires top management involvement and agreement, cross-functional involvement and enterprise-wide involvement. One of the main benefits of Portfolio Management is to know that the best set of projects has been selected. The Portfolio Management activity must be driven by a clear business strategy. The Portfolio Management process must fit smoothly with other company processes.

For the portfolio management process to be successful, the most important characteristics of development projects must be identified. They must have the same definition everywhere in the company. Otherwise it won't be possible to aggregate projects. All projects should be in the same portfolio, although they may aim to "grow revenues" or "cut costs". Projects of both types may use the same resources and lead to a similar result. Projects need to be categorised. Otherwise, important projects can get lost in the mass of less important projects. And, without categorisation, projects with very different characteristics may be compared, leading to conclusions that make no sense.

A top manager should own the Portfolio Management process. The Portfolio Management process should include activities to provide praise for good performance, and to provide ways to learn from problems. The activity of understanding the upper and lower boundaries of a project's value is beneficial because it encourages identification and understanding of project risks. Explicitly managing project risks helps product developers to increase project value. It's important to develop rules about the criteria for decisions to "continue the project" or to "kill the project" before these decisions are on the verge of being taken.

3.5 Learning from Experience

From experience working with many companies, lessons can be learned about success factors and pitfalls. From these lessons, others can understand and apply best practices and avoid the pitfalls. Many pitfalls are known. They have been experienced by the pioneers, and can be avoided.

3.5.1 *From the Trenches*

More than 80 % of the PLM Initiatives in which we've been involved have included business processes in their scope.

3.5.1.1 No Time for Processes

In this company, a world-leading machine manufacturer, a mid-level manager had been assigned to the business process improvement project. Our first meeting with the Technical Director, the owner of the project, went badly. He didn't appreciate the suggestion that the intention of the project was to improve performance. He seemed to think that the world-leading performance of the company was due to him, and that his part of the company needed no improvement. When the project manager launched the project, there was hostility from all the Product Managers in the company. They also reported to the Technical Director. They told him they didn't have time for talking about business processes, and couldn't take the risk of using new untried processes. All their time was needed for getting great new products to market. Not surprisingly, we didn't work long with that company. And before long, the unfortunate project manager, with no support from his boss, suffered a nervous breakdown and was off work for many months. A few years later, there was a global turndown in the company's markets, its products were no longer competitive and revenues dropped sharply. A new CEO was brought in, and he brought in a new Technical Director.

3.5.1.2 Unexpected Interest

In a global leader in the transportation industry, the COO was profoundly interested in the new business processes, and wanted to be fully involved. During the day, I would work with the team members. At the end of normal working hours, I would go to the COO's office and, for the next 3 h, we'd go line-by-line through the descriptions of the new processes. One evening, as I left after 9 pm, I ran into the Company President. He looked surprised to see someone in his executive suite at that time of day. I explained who I was, and what I was doing. Not only did he know about the project, but started discussing details.

3.5.1.3 Unexpected Reply

In another company in the machinery sector, we asked the Engineering VP for a copy of the working procedures. He replied that we shouldn't waste our time looking at them. He said they were only written to pass audits and didn't correspond to the real way of working. I may have looked surprised, because he added, "Customers buy our machines because they are the best in the world. They're not interested in knowing if our processes are documented according to some guidelines put together by a committee of bureaucrats".

3.5.1.4 Processes Aren't in PLM?

In another company, business processes were in the scope of the PLM Initiative. However, the manager of the Business Processes Group didn't assign anyone to participate in the Initiative. He said that business processes were his responsibility and not that of the PLM Team. The Initiative leader didn't want to confront him, as this wouldn't have fitted the company's culture of "harmony". Other people in the Initiative just got on with their work. Gradually the Initiative changed shape. Eventually it faded away.

3.5.1.5 Process and System (1)

On one occasion, I was asked by a company to help them implement a PDM system. As preparation, I reviewed the product development process. It was soon apparent that, by improving the process—independently of the PDM system—it was possible to reduce the time to market for some new products from 3 years to 3 months.

3.5.1.6 Process and System (2)

Another company had planned to develop new processes and support them with a PDM system. The new processes and system were implemented. Users had many issues with the system. The system was removed, and the new processes adapted to run without the system.

3.5.1.7 Too Much Mapping

A car manufacturer asked me to participate in a project looking at product data. It was a big project, expected to run for more than a year. It was high-profile, with a Steering Committee of top-level executives. The final presentation was to be made to the CEO. The Project Manager, who had worked for years in a Manufacturing plant, had followed best practice and created a cross-functional project team. It included representatives from more than 15 company functions. Project members came from across the product lifecycle, starting with Planning, Marketing, Design and Engineering, and ending with Service and End of Life. The team had decided to map the business processes that created and used product data. They'd bought a program to map the process. A young, dynamic team member from IS had been appointed to use the tool.

It didn't take long to find out that this was one of two projects in the company that addressed components of PLM. The other was led by someone from Engineering. It was focused on applications. It also had a cross-functional team, with members from Marketing, Design, Engineering and IS. But nobody from Production or Service. It was a strange situation. The two projects overlapped, and it was said that only one would be accepted for continuation by the CEO. The other would be killed.

The project looking at product data ran into problems. Firstly, its members from Marketing, Design and Engineering didn't contribute much. They said they weren't getting help from their organisations. Secondly, with more than 20 people providing information about processes, the "mapper", even though full-time on the project, soon got overloaded and couldn't keep up. A second person was assigned to mapping, but this created another problem as they didn't work the same way as the first person. The mapping tool worked well for small processes that fitted on one page. But it started to do strange things as some sub-processes began running over several pages, and sub-processes were connected across multiple pages. Pages got lost. Individual maps spread over dozens of pages of paper. Before long, the mapping activity was stopped. The team started process mapping again, this time focusing on the high-level processes. The results were good. A corresponding high-level data model was produced. Benefits, such as reduced time to market, and reduced costs were identified. Costs of a company-wide PDM system were identified. An impressive ROI was calculated. The project leader presented the project results to the CEO one morning.

That afternoon, the other project, the project focused on applications, also presented to the CEO. Their presentation wasn't made by their project leader, but by the VP of Engineering. He said that without the applications the project had identified, he wouldn't be able to guarantee getting new products to market on schedule. The CEO decided to go ahead with this project. And stopped the project that had looked at product data.

3.5.1.8 A Change of Situation

We were brought in by the CEO of a company in the process manufacturing sector. The company had about 5000 employees worldwide. Our job was to review the product development environment, compare procedures and practices to industry's best practices, suggest improvements, and develop an action plan. We found that although there were many product development projects, few new products were getting to market. Many projects were failing to achieve acceptance in the Final Prototype activity. Even apparently very small projects were taking a long time to come to fruition. Another problem was that there was no easy way for management to see the status of development projects. And sometimes it wasn't clear which criteria were being applied to decide if a project could move forward. Although the company had defined its business processes, there wasn't a methodology showing developers what they should be doing at each time during a project. At a more detailed level, there was incompatibility between the IS applications in use, with the result that there was data duplication between applications, and sometimes data was being manually re-entered. Misunderstandings arose in projects due to a lack of clear definition of particular words. There was confusion, for example, between product features and product characteristics, and between customer requirements and application requirements.

There was often a lack of agreement among the product development team members from different departments. People in Marketing felt their ideas and opportunities were being lost because R&D had no time to work on new projects. People in Production complained that "R&D's projects" interfered with their plant and production runs, costing them excessive set-up time, unnecessary downtime and reduced yield. Meanwhile people in R&D complained about the overload of work they faced. They complained about the continual demand for changes from Marketing. They complained about the huge volumes of paperwork they had to produce. They complained about the many meetings they had to attend. They complained about the lack of time to do anything useful for the project in the lab.

We carried out a quick study of the situation. It showed the need to introduce a well-defined cross-functional Stage and Gate process and methodology supported by a powerful IS application. It also showed the need to visualise the actual status of all projects, and that of the overall Project Portfolio. We recommended that a cross-functional project team be created to design and implement a solution to meet these requirements.

After implementation, the company measured a reduction in product development time of 20–30 %. Reasons for this included spending less time on re-development and corrections, and being able to make decisions faster. One of the main benefits seen was better definition of a project's target and specifications, validated with customers. This helped avoid costly re-design and late changes. Another benefit was that several man-weeks documentation effort per year, per team member, was eliminated. Most of this task was either eliminated or automated. After a couple of years, the company estimated it had increased its percentage of highly valuable product development projects by 100 %.

3.5.2 Business Process Improvement Approach

Many companies want to take a fast, lean approach to improvement of their business processes. For projects addressing business processes, we take an eight-step approach (Fig. 3.61). We've developed it based on experience gained in many process mapping, definition and re-engineering projects.

3.5.2.1 As-Is Situation

We get a cross-functional group of people from the company to document the current processes. The group should include people from all the functions in the

1	Prepare	Write down the scope and objectives. Plan the expected activities, taking care to include activities such as planning, communicating, reporting, interviewing, documenting, presenting and sustaining
2	As-is	Understand and document the as-is situation. Document the specifics of the As-is product lifecycle processes, activities and steps. Document input and output information. Document users and use of the information. Document objectives, performance measures, problems, requirements. Identify problems and weaknesses holding back performance. Identify waste. Identify the causes
3	To-be	Define 3 or 4 options for the to-be state. SWOT to get the best to-be state
4	Strategy	Identify several potential implementation strategies. SWOT to get the best implementation strategy
5	Plan	Develop a detailed implementation plan for an initial project and for further rollout phases
6	Communicate	Communicate a compelling case of success
7	Implement	Start small, get some success. Check results against targets. Communicate success
8	Sustain	When the initial project ends, start the planned follow-on activities

Fig. 3.61 Eight step approach to process improvement

product lifecycle such as marketing, engineering, production, sales, support and end-of-life. This enables inclusion of different views and requirements such as those of a customer, a design engineer, a cost engineer, a manufacturing engineer and a support engineer.

The first step is to create an overall process map. This will help the team position the individual processes. This overview may already exist in the form of a Business Process Architecture or a Process House. It may be documented in the company's ISO Manual or Quality Manual. The team can take a hierarchical decomposition approach. They start with the company's top-level business processes and go down, level-by-level, to individual tasks.

The next step is to list processes, showing their name, owner, objective, input, output and metrics. An "Overview Matrix of All Processes" is created. In the first column of the matrix, the processes are listed by name. Other information about each process, such as that shown in Fig. 3.62, is listed in other columns.

An "Individual Process Matrix" can then be made for each process. The team can "walk the process", step by step. They can identify all the tasks in the process and understand how they contribute to the goal of the process. In the first column of

the objective of the process	the last action in the process
the process owner	the event that happens at the end of the process
the roles involved in the process	the neighbouring processes
typical participants in the process	the documents used in the process
the customer of the process	the applications used in the process
the event that causes the process to be started	the procedures that apply to the process
the first action in the process	the process metrics

Fig. 3.62 Examples of information documented for each process

date of introduction	cost	roles
objective	expected benefits	number of users
scope	actual benefits	owner

Fig. 3.63 Characteristics of methods

the matrix, the roles can be listed. In the columns for each "role row", the activities for that role can be shown. At each level, the objective of each activity is documented. For each activity, the information input, created, used, and output is described, as are the sources and destinations of information. The cost of the activity is documented. The people involved in the activity and their roles are described. The frequency and execution time of each activity is indicated. Any applications used in the activity are identified, their information requirements described, and their interfaces with other applications detailed. Procedures and performance measures associated with the activity are described.

Any special methods (such as Design for Six Sigma) used at some stage of the product lifecycle are listed and documented. Their characteristics are documented (Fig. 3.63).

3.5.2.2 Towards To-Be

As the cross-functional group documents the existing processes, and the as-is process structure, they identify related issues, and document the problems that occur. They draw up a picture of things that have gone wrong, and things that should be avoided in future. Just as there's the opportunity for waste in any activity, there's the opportunity for waste in processes in the product lifecycle (Fig. 3.64).

The as-is processes and their problems are documented and analysed. The objectives for future processes are known, or developed, from the objectives of the project.

When the as-is process has been fully understood, the results of the above work are described in a report. The report is presented to project sponsors. This keeps them aware of progress. And it gives them an opportunity to respond to the findings.

3.5.2.3 To-Be

The next step for the cross-functional team is to identify possibilities for improvement of the as-is situation (Fig. 3.65). Improvements may result from eliminating waste, simplifying some processes and activities, and restructuring other processes and activities. Other improvements leading to an improved to-be situation can be made by introducing new technologies, applying software to

Overproduction	Doing more work on a project than is required, slowing other projects Doing more work on a task than is required Not creating a process description from a template, but from an empty page Creating information in a process that already exists in another process Repetition of the same activity in the same process, or in different processes Creating a duplicate value stream
Excess transportation	Pushing data to a distribution list, even when some people don't need it Multiple hand-offs of data in a process Excessive delegation of work Automated workflows with unnecessary steps Automated workflows that include steps only rarely relevant Changing processes frequently
Over-processing	Too many sign-offs in process activities Making glamorous presentations for a Steering Committee Approving documents that have already been approved Over-detailing a design
Inventory	Starting activities in a project before they are needed Defining processes that create information before it's needed Creating an inventory of waiting projects Atomisation of data. Producing data bit by bit Defining processes with unnecessary storage activities
Movement	Clicking though multi-level menus and lists Switching between multiple projects Process steps requiring search for drawings and other information Going to status update meetings
Defects	Forgetting to develop a risk management activity in a process Not developing a portfolio management process Making mistakes in processes, or in process documentation Making processes without quality control Documenting processes so badly they're impossible to understand Not documenting application workflow in a process description Not documenting a process Not updating a process description when the process changes
Waiting	Preparing training material long before people will be trained Waiting for sign-offs Waiting due to bottlenecks Waiting due to serial flow, instead of parallel flow

Fig. 3.64 Examples of wasteful activities in the product lifecycle

remove bottlenecks	eliminate gaps between activities
eliminate duplication of activities	define Key Performance Indicators
remove activities that don't add value	measure performance
combine activities	automate tasks in workflows
clarify roles	train participants
restructure tasks with frequent mistakes	develop missing documentation

Fig. 3.65 Actions to improve the process

automate mundane tasks, and taking advantage of best practices. Improvement opportunities are prioritised by ease of implementation and by size of impact.

Potential metrics for processes (Fig. 3.66) can be suggested. They will depend on the scope and circumstances of the process.

Potential metrics for methods will also depend on the scope and circumstances (Fig. 3.67).

number of processes in the company	number of tasks in a process
number of processes in the scope of PLM	number of times a process is executed annually
time to execute a process	percentage of identified processes completely defined
cost of process execution	number of participants in a process
number of roles in a process	difference between planned and actual process cycle time

Fig. 3.66 Examples of process-related metrics

the total number of methods	the cost of methods
the number of new methods introduced annually	the financial benefit of methods

Fig. 3.67 Examples of method-related metrics

3.5.2.4 To-Be Process Model

We get the team to develop the basics of a process model for the future situation. (We don't expect the team to develop a complete, fully-detailed business process architecture. That can be done later with the involvement of other people who have the corresponding specific skills and experience.) It doesn't take long to develop such a basic model. The intention is only to highlight the main processes and their relationships, and to identify the main activities in each process. Usually the team proposes several variants. Then they compare these, identifying the strong and weak points of each. And then they put the best parts together. The team's suggestions for the future situation are documented and presented to the project sponsors.

3.5.2.5 Benefits

The benefits of the new processes are often impressive. Cycle times have been reduced by up to 90 %. Significant reductions, sometimes as much as 50 %, have been made in workload. And visibility of process activity has been greatly increased. Sales have been increased because of faster, more accurate response to customers. Other improvements have included improved compliance and less rework cost.

3.5.3 Pitfalls of Business Process Mapping and Modelling

Business process mapping and modelling are frequent activities in PLM Initiatives. From experience gained by working with many companies, in many industry sectors, lessons have been learned. Many potential pitfalls in business process mapping and modelling (Fig. 3.68) have been seen. It's good to be aware of them before falling into them.

lack of management commitment	over-ambitious plans
unclear scope	trying to create 100% perfect process maps
failure to achieve user buy-in	not having enough qualified modellers available
over-documenting the current state	team weakness on cross-functional responsibilities
not making a plan for process mapping	people may not have the patience to map all details
not setting clear targets for mapping	people may not have the knowledge to map all details
believing processes work as documented	focusing on mapping ,and not on business improvement
lack of suitable Subject Matter Experts	only creating processes within departmental boundaries
manipulating processes to fit IS systems	input from only a few people, or unrepresentative people
unclear ownership and rules for modelling	launching a modelling activity unrelated to business needs
poor facilitation leading to poor results	not identifying hijackers (people with different objectives)

Fig. 3.68 Pitfalls of business process mapping and modelling

3.5.4 Top Management Role with Business Processes

3.5.4.1 In Control of Business Processes

Management needs to be in control of the business processes in the PLM environment. It needs to make sure that the best processes are being used.

3.5.4.2 Leading from the Top

To achieve the best business processes, management has to take the lead and show the way. There should be, at the highest level, a strong and widely-agreed desire for the best processes. Top management must show commitment to business process improvement. A single, unchanging theme for improvement is needed. There should be widespread awareness throughout the company of the reasons for improvement.

Improvement of business processes changes the way a company works. That's why it's so difficult. It changes the way processes fit together, changes the way people work, and changes the way IS applications fit together. This is what's needed for PLM, but it's hard work. And without management involvement and support, it won't happen.

3.5.4.3 The Right Structure

Management needs to set up a governance structure to ensure the best processes are first implemented and then continuously improved. An early task could to launch an Initiative, appoint a sponsor, set up a Steering Committee, select a Project Leader and create a project team. The team could start with a review of the current processes from initial product idea down to customer use and support, and eventual retirement and disposal. This will provide management with a solid base from which improvements can be made (Fig. 3.69). For example, activities that don't add value should be removed, and activities that were previously carried out in serial

organising activities so they meet the objective, and don't just mimic the current tasks
treating geographically dispersed resources as though they were at one location
melding parallel activities together instead of integrating their results
putting the decision point where the work is carried out
building control and feedback into the process
getting those who use the output of a process to perform the process
including information-processing work in the information-producing work
capturing information once, at the source

Fig. 3.69 Some possible improvements to business processes

should, wherever possible, be run in parallel. Process KPIs should be identified and targets set. Progress should be reviewed to make sure that improvements are being made.

3.5.4.4 The Right Culture

Management needs to make sure that the company has a culture that will allow it to go through a period of business process upheaval and transformation. There needs to be consensus at top management level that business process improvement is necessary. And a commitment to carry it through, even if it leads to some temporary problems. Top management must be willing to put a lot of time and effort into business process improvement. Middle managers must be supportive of the changes that will come. If they only pay lip service to business process improvement, while continuing to fight old departmental wars, progress will at best take much longer. At worst, performance will deteriorate. Product developers and other participants in the lifecycle must also support the business process improvement activity.

3.5.4.5 The Right Skills

Management needs to put in place the right people to work on business process improvement. To improve the business processes of the product lifecycle, a company needs to have people who can think horizontally (along the flow of the product lifecycle) and not just vertically (up and down the corporate hierarchy). The principal aim of business process improvement is usually to reduce cycle time. The company needs people who understand how the product is produced today, and have the right mix and range of knowledge and know-how to be able to see how it could be produced better in the future. It needs people at all stages of the lifecycle who can visualise how to work differently, have the skills to work the new way, and are willing to take the risk of working differently.

Chapter 4
Product Data in the PLM Environment

4.1 This Chapter

4.1.1 Objective

The objective of this chapter is to provide an introduction to product data in the PLM environment. The chapter aims to give a basic understanding of product data and related activities. It will also help readers to participate in activities related to product data.

4.1.2 Content

The first part of the chapter explains what product data is, and why it is relevant in a PLM Initiative. Definitions are given of frequently used terms in the product data environment. Examples are given of product data across the lifecycle. The management of product data in the twentieth century and in the twenty-first century is described briefly. The tools used to represent product data are explained. The need for modelling of product data is introduced.

The second part of the chapter addresses the situation of product data in a typical company. Product data issues are described. Typical challenges and objectives are outlined. A brief vision is given of product data in the future.

The third part of the chapter addresses some of the activities in a PLM Initiative that are related to product data. These include data modelling, data cleansing and data migration.

The fourth and final part of the chapter builds on experience of working with product data with many companies. An approach to product data improvement is described. Potential pitfalls of product data modelling are highlighted. Top management's role in the management of product data is addressed.

J. Stark, *Product Lifecycle Management*, Decision Engineering,
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4.1.2.1 Skills

Students in classes for which this book has been assigned will get, from this chapter, a basic understanding of product data in the PLM environment. They'll learn what product data is and why it's important. They'll be able to explain, communicate and discuss product data.

In addition, they'll learn how product data is documented. They'll know about product data models and product data modelling. They'll learn about the problems and opportunities with product data in the PLM environment of a typical company. They'll be able to describe the typical activities of a product data improvement sub-project in a PLM Initiative. And they'll be aware of some companies' experience with product data improvement sub-projects in PLM Initiatives.

4.1.3 Relevance of Product Data in PLM

Product data is a main component on the PLM Grid (Fig. 1.5). In many ways, product data is the product.

Product data is the definition of a product. It's all the knowledge and know-how about the product. In addition, it's all the knowledge and know-how about the way the product is designed, manufactured, supported, used and recycled.

The quality of product data is a key element of product success. One small error can cost millions of dollars.

Product data is very valuable. If an unscrupulous competitor gets access to the product data, they will know everything about the product.

The right product data enables a company to sell and support its products effectively. If the company can't control its product-related data, it will find it difficult to manage its products. If a change is needed to the product, for example because of changing laws or regulations, the product data enables quick change. The product data is the basis for the next generation of the product.

Managing the product across its lifecycle isn't easy. During the development of a product, it doesn't physically exist. Not surprisingly, during that phase of life it's difficult to control. Once a product does exist, it should be used at a customer location, where again, it's difficult for a company to keep control of it. A lot of the time, all the company has access to is the product data. And not the product.

Whatever the product made by a company, an enormous volume and variety of product data is needed to develop, produce and support the product throughout the lifecycle. Many products contain a lot of parts or components or ingredients (Fig. 1.2). And behind them is an enormous amount of information.

The amount of product data needed to define a part or component varies widely from one product to another. As an example, one company I worked with had about 100 mechanical parts in its products. Each of these was defined by about 20 documents (design, manufacturing, test, reviews, service, recycling, regulatory, quality, etc.). On average there were about 40 important items of data on each

Fig. 4.1 Requirements for product data

under control	reusable
high quality	lean
secure	complete
available when and where needed	accurate
seen as a strategic company asset	easy to find

document. And, on average, each document went through 10 versions. The resulting amount of product data can be thought of in different ways. 800 important items of data. Or about 20,000 documents. And that was for one product. The company had about 300 products. 25 % of the data items existed on more than one document. And 80 % of data was common across a product family. In such an environment there are many ways to organise the product data. Some are better than others.

Companies have a choice. They can organise their product data badly and, for example, take 30 min to find a document. Or they can organise their product data so that they can find a document in 30 s. They can leave product data disorganised so that it takes 2 h of manual work to create a report. Or they can organise it and create the report automatically in 2 s. They can let people waste time by re-entering the same data several times. Or they can make sure data is only entered once. The requirements for product data are clear (Fig. 4.1).

If product data isn't managed effectively, the result will be wasted time, rework costs, and slow time to market. Product data doesn't look after itself, and like anything that's not properly organised and maintained, won't perform as required. Over time, it will slide into chaos and decay. However, this has to be avoided as the slightest slip can have serious consequences for the product and those associated with it. Getting product data organised, and keeping it organised, are major challenges in PLM.

4.2 Definitions and Introduction

4.2.1 Definitions

4.2.1.1 Product Data

The term "product data" includes all data related both to a product and to the processes that are used to imagine it, to design it, to produce it, to use it, to support it, and to dispose of it.

The data has many purposes. Some of this data will describe the characteristics of the product, or a part of the product, or its packaging, or a label, or an identifier. Some will describe a structure such as a BOM or a list of ingredients. Some will describe a process related to the product, how something has to be done. Some of the information may describe a regulation with which the product must comply. Some may describe a best practice guideline developed by an industry organisation or an international standards organisation.

Product data is created and used throughout the product lifecycle. Some product data (e.g., part geometry) is created within the engineering function, some is created elsewhere (e.g., feedback results from customers in field tests). Some of the data (e.g., circuit analysis results) is used within design engineering, some (e.g., welding instructions) in production, some (e.g., installation instructions) on a customer site, some (e.g., disassembly instructions) at the end of the product life.

4.2.1.2 Product Data Management

Product data management is the activity of managing product data. A PDM system is a computer system, an application, which manages product data.

4.2.1.3 Data Model

A data model is a representation, usually a diagram, of the data in a particular environment. There are many types of data model. They have different objectives, are used in different circumstances and have different content.

4.2.1.4 Conceptual Data Model

A conceptual data model is a high-level data model that people throughout a company can understand. It shows, from the user viewpoint, the main entities (e.g., part, drawing, list of ingredients, User Manual) and the relationships between them. It may also define the entities, and show their attributes and structure. A conceptual data model doesn't include any dependencies on the particular technologies (e.g., database) on which it may be implemented.

In this introductory chapter about product data, the focus is on the conceptual data model. Many benefits arise from making a conceptual data model (Fig. 4.2).

help identify business requirements for product data	develop common definitions of product data entities
help people working with product data to discuss it	provide a basis for software development
help people using product data to understand it	identify opportunities to reuse product data
help get agreement about product data	identify key data element attributes
provide a documented description of product data	identify ownership of data elements
ensure that product data is reliable and consistent	work with product data in a consistent, standard way
avoid redundant / duplicate / conflicting data	manage product data as a strategic company asset

Fig. 4.2 Benefits of making a conceptual data model for product data

4.2.1.5 Logical Data Model

A logical data model is a much more detailed model than a conceptual data model. It shows all the details about the entities that are required for the business to function normally. It shows all the rules governing their behaviour. Very few people in the company will know about all these details. Like the conceptual data model, the logical data model doesn't include dependencies on particular technologies on which it may be implemented.

4.2.1.6 Physical Data Model

A physical data model is a very detailed model that is specific to the technology (e.g., database) on which it will be implemented. It shows how the data will be physically stored and accessed.

4.2.1.7 Entity-Relationship Model

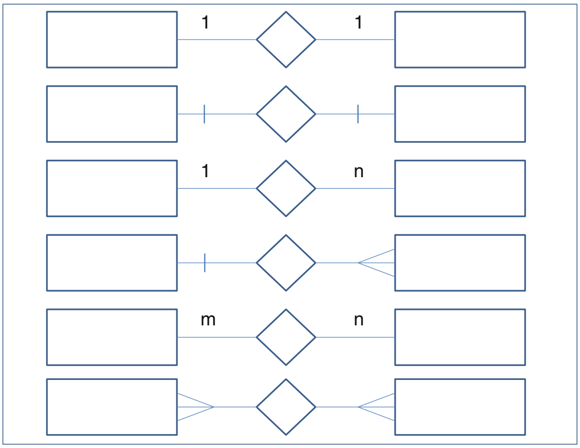
Entity-relationship models have been used since the 1970s. In this modelling technique, an entity is any physical or logical object of interest in the environment being modelled. Customers, products, suppliers, processes, locations, machines, money, documents and employees are among the many examples of entities. There are also many possible relationships. For example, one entity may use another entity. One entity may own other entities. One entity may contain another entity.

An entity doesn't represent an individual item (an instance), but a class of similar items, each of which can be characterised in the same way and will be used in the same way in the environment being modelled. Examples of entities in a particular environment could include aircraft, manufacturer and airport.

The common properties and characteristics of an entity are referred to as its attributes. Examples of an aircraft's attributes could include colour, weight, fuselage length and wing span. Attributes of a manufacturer could include manufacturer name and assembly plant location. Relationships are associations that describe the link between entities, for example between an aircraft and a manufacturer.

Graphically, entities are often represented as rectangular boxes, attributes as circles or ellipses, and relationships as diamonds. Lines associate entities and relationships to their attributes. Annotations indicate the nature of relationships: one-to-one, 1:1; one-to-many, 1:n; many-to-many, m:n (Fig. 4.3). Alternatively, single-headed or double-headed arrows can be used to indicate the nature of the relationship.

Fig. 4.3 Entity relationships



4.2.1.8 Configuration, Configuration Management

The configuration of a product is a definition of all its configuration items (e.g., component, specification document, etc.) and of the way they are organised.

Configuration Management (CM) is the activity of documenting initial product specifications, and controlling and documenting changes to these specifications. CM is a formal discipline to help assure the quality and long-term support of complex products through consistent identification, and effective monitoring and control, of all of this information.

Configuration Management is a discipline that has existed for over 50 years. It has many standards and guidelines (e.g., ISO 10007:2003 Quality management systems—Guidelines for configuration management). ISO 10007:2003 provides guidance on the use of configuration management within an organisation. Applicable across the product lifecycle, it describes the configuration management responsibilities and authorities, the process and the planning, as well as the four activities (Fig. 4.4) of configuration identification, change control, configuration status accounting and configuration audit.

The data that is managed within Configuration Management is product data.

Name	*Activity*
Configuration identification	determining the product structure, selecting configuration items, documenting items, interfaces and changes, and allocating identification characters or numbers
Configuration control	addresses the control of changes to a configuration item after formal establishment of its configuration documents
Configuration status accounting	is for formal recording and reporting of the established configuration documents, the status of proposed changes and the status of the implementation of approved changes
Configuration audits	are carried out to determine whether a configuration item conforms to its configuration documents

Fig. 4.4 Four activities of configuration management

4.2.2 *Product Data Across the Lifecycle*

A lot of data is created and used in a company as a product is developed, manufactured, supported and retired. Figure 4.5 shows some of the data that is needed across the product lifecycle for various products. Each company will have its own set of product data. The content depends on a variety of factors including its industry sector, its position in the supply chain, and the way it's been organised in the past.

In each phase of the lifecycle, there may be many users of product data (Fig. 4.6). The number of users of product data varies from one company to another. However, it isn't unusual for more than 25 % of the people in a company to create or use some form of product data.

4.2.3 *Organising the Product Data*

4.2.3.1 Departmental Focus

For most of the twentieth century, companies were organised by functional departments such as Marketing, Engineering, Manufacturing and Sales. People and work were assigned to a department. Then, for example, people in Engineering worked the way the boss of Engineering told them to work. They created documents to fit the needs of Engineering. They used Engineering jargon on their documents. They stored data in Engineering databases. Meanwhile, people in Manufacturing worked the way the boss of Manufacturing told them to work. They

Imagine	*Define*	*Realise*	*Support/Use*	*Retire/Recycle*
Ideas	Cost estimates	Label data	Field data	Disassembly lists
Proposals	Requirements	Process plans	Customer complaints	Recyclable codes
Drawings	Regulatory rules	MBOMs	Service manuals	EOL notification
Models	EBOMs	Fixture designs	Installation documents	Recovery procedure
Sketches	Assembly drawings	Welding instructions	SBOMS	Disposal lists
Results of reviews	Ingredient lists	Cleaning guidelines	Repair procedure	Part-out plans
Cost estimates	Master data	Change requests	Spare part policy	Teardown reports
Idea scores	Risk reports	Quality findings	Sensor reading lists	Change requests

Fig. 4.5 Examples of product data across the product lifecycle

Imagine	*Define*	*Realise*	*Support/Use*	*Retire/Recycle*
Developers	Design engineers	Welders	Maintenance	Recyclers
Shop Floor workers	Product Managers	Machinists	Mechanics	Disassemblers
Customers	Customers	Assemblers	Customers	Salvors
Partners	Suppliers	Testers	Service engineers	Customers
Marketers	Regulators	Cleaners	Repair workers	Dismantlers

Fig. 4.6 Typical product data users across the product lifecycle

created documents to fit the needs of Manufacturing. They used Manufacturing jargon on their documents. They stored data in Manufacturing databases.

There are so many products and so many parts in products, that special identifiers are needed to know exactly which "thing" is being referred to in situations as diverse as defining a product, assembling the product, controlling stock levels, ordering, billing, accounting, and handling complaints and returns. To make things easier for themselves, the departments often used "speaking numbers" (also referred to as "significant numbers", "intelligent numbers", "meaningful numbers" and "coded numbers") to identify parts. These numbers were helpful as they said something about the product or part. For example, L20-US-P1 could refer to a 20 inch product sold in the US in package 1. L20-JP-P4 could be the same product sold in Japan in package 4. L20-GE-P8 could be the same product sold in Germany in package 8. (A "non-speaking" number such as 40012741 or 40012742 doesn't provide such help.)

Some departments used tabulated documents to make their life easier. For example, instead of making 12 separate drawings, each with its own name and identifier, of similar parts, they made a drawing of one of the parts. Then, on the same sheet of paper, they created a table showing the characteristics that change from one part to another.

4.2.3.2 Paper

For much of the twentieth century, paper was the main medium for storage and communication of product data. The paper on which the product data was written was given a variety of names (Fig. 4.7). The meaning of these names wasn't standardised. As a result, the collection of product data that was referred to in one company or department as a record would be referred to in another company as a report. A policy for one company or department would be a procedure for another and an instruction for a third.

Usually, on a paper document containing product data, one part of the document would have a particular structure reserved for information about the rest of the information on the document. A drawing on paper, for example, often had an informative "title block" with fields for information such as drawing title, identifier, scale, units and creation date. A paper text document had a "header" with fields for information such as document name, product name, creation date and author name.

record	form	report	procedure	policy
directive	guideline	rule	list	standard
template	document	protocol	sheet	chart
drawing	file	folder	bill	instruction
plan	diagram	schedule	log	order

Fig. 4.7 Paper documents with product data

slow search	slow distribution	easy to misplace or lose
hard to access	high storage costs	hard to keep track of copies
hard to share	slow access	risk of deterioration and damage

Fig. 4.8 Some issues with paper documents

Although paper has a lot of advantages as a storage and communication medium, it also has some disadvantages (Fig. 4.8).

4.2.3.3 Document Management Group

Many companies had a special Document Management Group to manage all the paper. This wasn't seen as an important organisation. It was often located in a basement. It was usually staffed by people close to retirement. From experience they knew a lot about the company's documents. Often, they had a "Bible", a book in which they wrote down the names and numbers of documents. Their other main tools were reprographic equipment, filing cabinets, pens and pencils. Blueprints and other large documents were laid out in drawers in horizontal cabinets. Procedures and meeting minutes were stored in files on shelves or hung in vertical cabinets.

By the 1970s, a lot of product data was being produced and stored on computer files. These brought new issues (Fig. 4.9). In the 1980s a lot of product data was stored on 3½-inch floppy disks designed to fit in an engineer's shirt pocket. Product data became increasingly difficult to manage. Sometimes the information on a file would also exist on paper, sometimes not. Sometimes the paper would be managed by the Document Management Group, sometimes not. In a large organisation, it's almost impossible to manage file-based data efficiently. Users lose track of their data in a sea of files. There's a lot of data redundancy. Duplicate items of information are held in several applications. It's difficult to share data between applications. It's difficult to control access and to maintain security of data across several independent file-based applications. It's difficult to apply uniform rules and standards to data that are held in several file-based applications.

In the 1980s, special systems were developed to manage "engineering data". Some were known as Engineering Drawing Management Systems or Engineering Data Management Systems. Others were known as Engineering Document Management Systems or Engineering Information Management Systems. Then, in the 1990s, Product Data Management Systems appeared. All these systems handled many data management tasks, reducing the need for Document Management staff. Many needed extensive customisation, which called for IT skills. This changed the required skills profile for Document Management staff.

slow to search	data redundancy	naming
hard to access	hard to keep track of copies	security problems

Fig. 4.9 Some issues with files

4.2.4 Product Data as a Strategic Resource

By the end of the twentieth century many changes were affecting product data and its management. Most product data was now electronic. There was pressure to reduce time to market. Companies were grouping activities into business processes, and organising around these processes. The old departmental approach to product data wasn't helping. Errors occurred. Time was being wasted. Product data needed to be usable for all users, not just those in the department where it was created.

A new, organised approach was needed. Product data was seen as a company resource. As for all other company resources, it had to be proactively managed. Out went paper and pencil, and in came concepts such as databases, metadata, product data architecture, data modelling, document templates, and serial part numbering.

It was recognised that product data is more complex than data in other areas of a company. Transactions on other business data typically last a few seconds or minutes. A transaction involving product data, such as the design of a new part, will generally last several hours or days. Other business data (e.g., about customer reservations, invoices, suppliers, etc.) has clearly defined sizes. Product data is different. One product may be made up of 10 parts, another of 10,000 parts. A CAD file describing one part may be 1 MB. That describing another part may be 1 GB. Multiple documents may be needed to specify, or validate a part or a product. Each part may have multiple versions. Each product may have multiple variants. It may take years to develop a part, and during that time information may be in any one of several states. And once the product has been developed it may have a life of 50 years or longer, during which product data may change at any time. In the usual business data environment, the relationships between data are generally static, well specified, and simple. For product data, they are frequently changing, unclear, and complex. They are characterised by versions and alternatives. These occur less frequently in the business environment. In the business environment, modification to one record won't normally lead to modifications to a large number of other records. With product data, modification to one record, say a part design, could lead to a large number of modifications to related records. Product data structures are more complex than those in other business areas. For example, the information structure of a car made of 20,000 parts is more complex than that of the monthly invoice you receive from your telephone company.

Most electronic business data in a company is stored in a database containing tables with records of fixed length. But a lot of product data doesn't have a fixed length.

Much of the product data will be company-specific. In other areas, for example, preparing the company accounts, many companies will work to an international standard, for example, the International Financial Reporting Standards (IFRS). The words used will either be drawn from everyday language or based on standard descriptions. The meaning of words is understood worldwide (Fig. 4.10).

However, the product world contains a lot of technical terms and company-specific jargon that makes no sense to people from other companies (Fig. 4.11).

revenue	cost of revenue	gross operating profit	S, G and A expenses	pre-tax income

Fig. 4.10 Business terminology understood by many

calender	digester	hooker	jig	wet scrubber

Fig. 4.11 Product terminology understood by few

4.2.4.1 Metadata

Metadata is "data about data", "data describing other data". It's the key information about a larger volume of data, such as its name, its status, its location, and its owner. Metadata is similar to the catalogue information of a book in a library. That might contain the book title, author name, book number and book location. The amount of metadata is usually much, much smaller than the amount of data it describes. For example, there might be just 10 metadata for a 400-page book in a library catalogue.

For a 50 kB text document, there might be just 20 metadata. 40 metadata may describe a 1 MB CAD object. Even though there's not much metadata, it's very helpful when identifying, managing and accessing product data.

The metadata describing a particular type of product data has a fixed length. Product data management systems put the metadata in the database.

In the paper world, metadata was put in the title block or header of the paper document. And then in a paper catalogue. In the computer world, metadata is put in a database.

There are different types of metadata. For example, there's administrative data such as file size, type, creating application, and time stamps. There's descriptive metadata such as object type, object identifier, title, subject matter, and owner. There's structural metadata such as the link between a drawing and a part, or the links between sub-assemblies and a product.

The metadata of a file could include the name of the file, its title, its type, the application that it was created with, the location of the file, its size, its lifecycle state (such as in-work, under review, in rework, approved, rejected, cancelled), its creation date, the date last modified, the date last accessed, permissions (such as who can read it and who can modify it), the author, its status (checked in, or checked out), and by who it was last saved. With less than 20 metadata, it's possible to get a good overview of the file. Yet the file itself could, for example, hold the results of 20,000 measurements of pressure and temperature at various positions on the product.

The metadata of a word processed document file could include a lot of useful information about the file (Fig. 4.12).

With less than 25 metadata, it's possible to get a good overview of the word processed file. Yet the file could contain dozens of pages of detailed description of a market segment or a new product.

document title	subject	name	creator	type
reviewer	format	creation date	date last modified	access rights
description	source	template	location	structure
lifecycle state	dependencies	classification	attachments	author
owner	usage	version	iteration	

Fig. 4.12 Some metadata of a word processed file

Similarly the metadata of a CAD drawing file could include a lot of useful information about the file (Fig. 4.13).

And the metadata of a part (Fig. 4.14) gives a good overview of the part.

4.2.4.2 Product Data Architecture

An architecture defines the components in a particular environment and shows how they're organised and related. There's so much product data in a company that companies often create a product data architecture with models showing how data is organised. Related procedures, standards and rules about data creation, use and storage are defined. A correctly-organised, coherent product data architecture will enable effective working across the product lifecycle.

4.2.4.3 Product Data Modelling

Product data is needed across the lifecycle (Fig. 4.5). The scope of the product data environment is wide. It's a complex environment. It's not easy for newcomers to understand. Simple models of product data are needed to help people understand and communicate about it. A model acts as a common basis for discussion and communication. It shows the main objects in the environment, their attributes and their relationships. It helps people increase understanding and share a common view.

drawing number	type	title	date created	date modified
date reviewed	date released	page number	sheet number	drawing owner
revision level	reviewer	approval date	approver name	drawing scale
releaser	drawing format	contact name	drawing size	standards

Fig. 4.13 Some metadata of a CAD drawing file

part number	part superseding	part description	part superseded
drawing number	make/buy source	unit(s) of measure	cost
revision level	lead time	dependencies	certifier
creating system	status	price	colour

Fig. 4.14 Some metadata of a part

4.2.4.4 Product Data Rules

With huge volumes of product data, and many people working with it, there's potential for chaos. To avoid the system breaking down, procedures and rules are needed.

For example, the number of a part should be unambiguous so that it's clear to which part it refers. Serial numbers should be used for parts as they are unambiguous. A serial number is a unique number assigned to a part. It differs from the unique numbers assigned to other products of the same type by a multiple of a particular number. Often the particular number is one. 40012741 or 40012742 are examples of serial numbers.

Speaking numbers should be avoided as they aren't unambiguous. In some situations, significant numbers lead to misunderstandings and problems. For example, L20-US-P1 may refer to a 20 inch lamp in the US, but in Germany the product may be measured in cm, so the equivalent of the L20-US-P1 in Germany may actually be the L51-GE-P8 and not the L20-GE-P8. And when sold in Poland, perhaps the equivalent of the L20-US-P1 is identified as L51-PO-P8. But in Portugal, perhaps it's also identified as L51-PO-P8. When a L51-PO-P8 is sent in for upgrade from someone who has moved to France, it's difficult to know if it should be upgraded to Polish specifications or Portuguese specifications.

Similarly, tabulated documents should be avoided as they create confusion. The single tabulated drawing that represents 12 separate parts has one name and identifier. That's OK until something changes. Then it can be difficult to understand if the change affects just one of the parts, or several, or all. And it can be difficult to document the change without affecting unchanged areas.

Instead of creating new documents from scratch, existing document templates with pre-defined metadata fields should be used.

A list of all document types should be maintained. For each document type it should show information such as name, number, owner, version number, creation date, etc.

4.2.4.5 Managing Product Data

Product data is different from most data in a company, but the same basics of data management apply. Objectives for data management have to be defined. They have to be documented. Meaningful Key Performance Indicators (KPIs) have to be identified. Targets for them have to be set. People have to be trained. Performance has to be measured. It has to be reviewed to make sure things are working well, and to see what improvements could be made.

4.2.5 Tools to Represent Product Data

It's possible to make a product data model with simple tools such as a pencil and a piece of paper.

Tools such as Excel and PowerPoint can also be used to document the current and future situations of product data. These may not seem to be highly sophisticated. However, they're widely available, usable by most people, and understandable by most people.

More sophisticated software tools are available to provide support for data modelling. They can be of great benefit in modelling, since the amount of data generated by the modelling activity, and the frequent updates and changes, can be difficult to handle by purely manual means. But, these tools often require additional training and licensing. The ease with which such software allows modelling to take place shouldn't be allowed to distract people from making sure that what they're modelling is correct and of use to the business. It's only too easy, when modelling product data, to lose sight of the target. A very detailed data model will be of little use if the PLM Initiative stops before the model is completed.

The various languages available for modelling often have a number of different types of "diagram" (or "maps" or "domains") that show different aspects of an object or an activity. These include for example, the structure of objects and activities, their development, how they communicate, and how they're related to other objects and activities.

4.2.5.1 UML

One of the languages used is the Unified Modelling Language (UML). This was mentioned in Chap. 3. It has many types of diagrams that are used to show information about objects and activities. The diagram types can be divided into three categories: Structure Diagrams; Behaviour Diagrams; and Interaction Diagrams. Structure Diagrams represent static structures and include the Class Diagram (Fig. 4.16), Component Diagram and Object Diagram. The Behaviour Diagrams include the Activity Diagram, State Machine Diagram (Fig. 4.20) and Use Case Diagram (Fig. 3.18). They represent various types of behaviour. The Interaction Diagrams represents interactions, and include the Communication Diagram, Sequence Diagram, Timing Diagram, and Interaction Overview Diagram.

4.2.6 Data Model Diagrams

The most frequently used models of product data are used to show its flow and its structure.

4.2.6.1 Data Flow

Figure 4.15 shows the flow of data from a Sales Engineer to a Design Engineer and then to a Manufacturing Engineer. The "Detail the design" activity is represented by a box characterised by the information on three arrows. The input arrow shows the input necessary to perform the activity, and the output arrow shows the output of the activity. The third arrow, the vertical mechanism arrow, shows the means by which the activity is accomplished. Activity boxes are linked on a diagram to show the overall environment. The output of one activity is the input for another.

The principles behind such a model are simple and easy to understand. Creation of a model for a small activity is quick and easy. But creation, change and management of models with hundreds of activities and participants takes a lot of time and effort.

Data-flow models can show how data flows through the lifecycle, and by which activities it's processed and stored. Data-flow models relate the various activities of the PLM environment to the use and flow of data.

Typically, data-flow modelling is carried out as a top-down exercise with as many decompositions or hierarchical levels as necessary. The environment is first described at the top level, Level 0. Then each element of the top level is separately described in more detail.

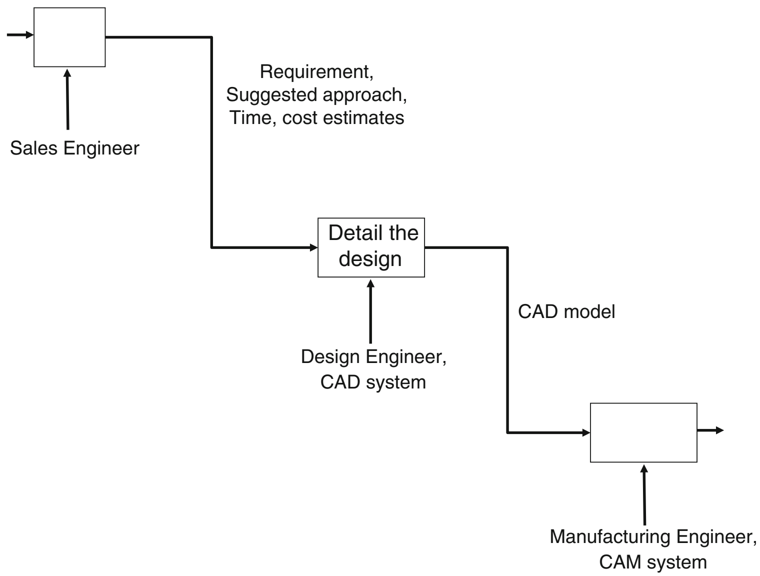


Fig. 4.15 Data-flow diagram

4.2.6.2 Class Diagram

The Class Diagram is used to show the static structure of a system. It shows the system's classes, their attributes, and the static relationships between classes.

In the class diagram, a class is represented by a box with three parts (Fig. 4.16). The upper part shows the name of the class, the middle part shows the attributes of the class, and the bottom part shows the class's operations. These are the operations or methods performed by the class. As there may be many attributes and operations, sometimes some attributes aren't shown, and sometimes the operations aren't shown at all.

The "Person" Class would have attributes such as Name, Date of Birth, Height and Weight. Each person (member of the "Person" Class) has these attributes, but has their own value for each attribute.

A person with the Name of John Smith is a member of the Person Class, with a Date of Birth value of January 1, 1981, a Height value of 5 ft 10 inches, and a Weight value of 220 lb.

All instances of a class have the same attributes and relationships. So, for example, all drawings of the Drawing Class would have an attribute of Number. But they would all have a different number.

A line can represent the relationship between classes. An arrowhead indicates the role of the entity in the relationship. Numbers at each end of the line indicate the multiplicity.

The Part-Drawing Relationship (Fig. 4.17) shows that a Drawing can exist without a Part (0), but that a Drawing can be associated with many Parts (n). A Part doesn't necessarily have a Drawing (0); but a Part can be associated with many Drawings (n).

The Part-Colour relationship (Fig. 4.18) shows that a Colour can exist without a Part (0), but that a Colour can be associated with many Parts (n). A Part always has exactly one Colour (1).

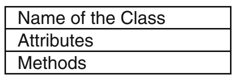


Fig. 4.16 A class is represented in three parts

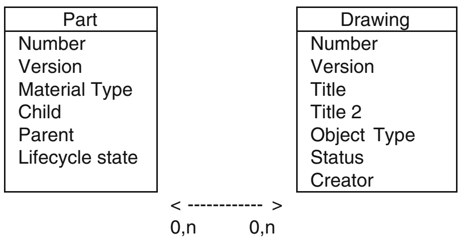
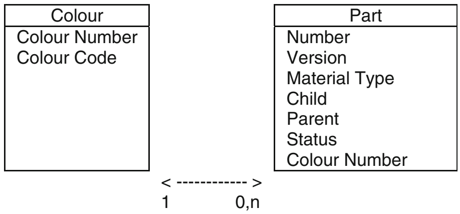


Fig. 4.17 Part-drawing model

Fig. 4.18 Part-colour model



The Part-Part relationship in the model in Fig. 4.19 shows that parent-child relationships are possible. A Part-Part relationship is used to show a part belongs to a sub-assembly, or a sub-assembly belongs to an assembly.

4.2.6.3 State Diagram

A state diagram shows the states that exist for an entity, and the allowable transition paths between them.

Figure 4.20 shows four possible states for an entity.

When the entity is In Work, the only allowable transition is to the Under Review state. When the entity is Under Review, the allowable transitions are to In Work, Released and Cancelled states. When the entity is in the Released state, the only allowable transition is to the Cancelled state.

Some entities in the PLM environment have the same lifecycle, some have different lifecycles. Figure 4.21 shows the lifecycle states of the objects A, B, C, D, E and F.

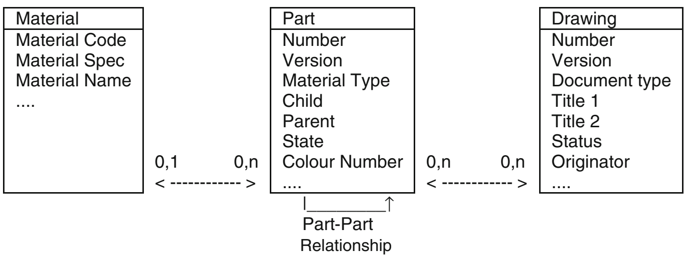


Fig. 4.19 Material-part-drawing model

Fig. 4.20 A state diagram

	Lifecycle	*State 1*	*State 2*	*State 3*	*State 4*	*State 5*
Object						
A		In Work	Completed	Cancelled		
B		In Work	Under Review	Released	Rejected	Cancelled
C		In Work	Under Review	Complete	Cancelled	
D		In Work	Under Review	Released	Rejected	Cancelled
E		In Work	Under Review	Released	Complete	Cancelled
F		In Work	Under Review	Approved	Accepted	Cancelled

Fig. 4.21 Object lifecycle state table

4.2.7 KPIs for Product Data

A Key Performance Indicator (KPI), or metric, is a quantifiable attribute of an entity or activity that helps describe its performance. It's something that can be measured to help manage and improve the entity or activity. Many KPIs can be used to measure product data performance (Fig. 4.22). KPIs help an organisation to set targets for its annual improvement plans and to measure the progress that it's making. For each metric there's a current value and there can be target values for the future.

4.2.8 The Importance of Product Data in PLM

Throughout the product lifecycle, product data is all-important. In many ways, product data is the product. It has to be available whenever it's needed, wherever it's needed, by whoever needs it, throughout the product lifecycle. Product data is all that people can work with when the product doesn't physically exist in their environment.

Product data is a strategic resource. It defines and describes the product, and the product is the source of company revenues. Product data can be reused in the next generation of a product generating future revenues.

A company's product data represents its collective know-how. As such it's a major asset and should be used as profitably as possible. If there's something wrong with product data, then there will be problems with the product and money will be lost.

The product that the customer will eventually use is designed and manufactured using product data. This means that customer perceptions of the product are

% of product data that is duplicated	% of product data that is electronic
% of product data that is incorrect	% of product data that is not under change control
% of product data that is incomplete	% of product data that has been lost
% of product data that is never used	volume of data that is re-entered manually
% of product data that has no owner	number of different copies of same document

Fig. 4.22 Examples of KPIs for product data

functions of the product data. And the quality and cost of the product are functions of the product data.

In the PLM environment, product data is a major input to business processes. It's also a major output from business processes. Without knowing the product data in detail, it will be difficult to optimise business processes. In the PLM environment, many applications create, use and manage product data. Without knowing the product data in detail, it will be difficult to use these applications to the best.

The objectives of a PLM Initiative may be related to a KPI of product data (e.g., % of clean product data).

4.3 Reality in a Typical Company

The details of the product data environment are different in different companies. However, there are many similarities in their activities addressing product data. They face many similar issues related to product data. It's never easy for them, and sometimes impossible, to separate product data issues from other components of the PLM environment. Companies face similar challenges with product data. They usually have, or are developing, a vision of product data in the future.

4.3.1 Generic Issues with Product Data

There are many types of product data, each with its individual characteristics. However, although some characteristics are specific to just one type of data, many issues are common to many or all types (Fig. 4.23). These issues are all potential sources of problems to be addressed in PLM.

Access to product data has to be provided to people when they need it. However, access to product data has to be controlled so that only authorised people, with specific rights, can access the data. Product data needs to be available to users where they need it, when they need it. Product data can be in various states. Different rules apply to access of data in different states. Across the product life-cycle, people want to work with the product in the most appropriate way for their activity, and they want to work with the most appropriate structure of product data. Different users want to see different views of product data. Traceability is a requirement in many industries. An audit trail is needed to show which actions were taken on data.

Volume, Variety, Vocabulary	Status, Change, Version	Users, Access, Availability
Definition, Content, Structure	PRODUCT DATA	Ownership, Value, Meaning
Representations, Media, Source	Numbering, Naming	Security, Confidentiality

Fig. 4.23 Issues common to many types of product data

There are many applications in the PLM environment. Most of them create and store product data in different ways. This complicates access to, and management of, product data. It complicates transfer of data. A lot of data is in files, but people are much more interested in real objects, such as products, than in file structures.

A lot of product data must be kept for a long time. Requirements vary by industry, but customers and regulators may require data to be kept for several decades. In some cases, it may be needed for more than 50 years.

Most product data undergoes change at various times in its lifetime. Unless changes are carefully managed, configuration control may break down. And then configuration documentation no longer corresponds to the actual product.

Product data is valuable. Much of it is confidential, and shouldn't be seen by people in other organisations, such as competitors. A company's product data represents its collective know-how. Yet many companies are unaware of its value. And the ownership of product data is often unclear.

Unique numbers are needed to identify every object, e.g., document, which defines a part or product. Every object has to be defined. When there's not a standard definition, there can be multiple definitions, and all the definitions can be different.

Mistakes with product data can be expensive, but it's easy to type the wrong character.

Documents are often annotated informally. In many cases, this important information will be lost forever. And, due to informal communications between departments, other important product-related information may disappear.

There can be a lot of product data in a company (Fig. 4.24). It can be in many locations. It can be in a database, in an application, in a file, in a drawer, on a piece of paper on someone's desk, in someone's head.

Product data has to be managed on a variety of media. Yet some media deteriorate over time. There may be specific problems with data representing a product's software.

Raw data has little meaning, and is of limited use, yet often only raw data is kept.

People can waste time looking for product data. Re-inventing existing product data introduces errors and wastes time.

Analytic models	Analysis results	Assembly drawings	As-built configuration	Bill of Materials
CAD geometry	Consumables lists	Cutaways	Engineering drawings	Change data
Costing data	Customer requirements	Disposal lists	Design specifications	Cutsheets
Equipment logs	Equipment data sheet	Exploded views	Factory layouts	Failure reports
Flowcharts	Formulae	Functional specs	Label information	Ingredients list
Line lists	Machine libraries	Maintenance info	Material certification	Mounting data
NC programs	Packaging standards	Parts classifications	Parts lists	Patent reports
Photographs	Pipe specifications	Pneumatic diagram	Process model	Project flows
Project plans	Process plans	Purchasing data	QA records	Recipes
Regulatory rules	Results of calculations	Scanned drawings	Schedules	Service lists
Service manuals	Shop floor instructions	Simulation results	Sketches	Software
Spare part info	Specifications	Standards	Standard costs	Status logs
Test data files	Technical publications	Test results	Tool designs	User guides
User manual	Validation reports	Versioning data	Wiring diagram	Video files

Fig. 4.24 Examples of product data

Terms	*Issues*
Research, develop, discover, design, ideate, imagine, invent, innovate, conceive	Are they the same? Are the differences clear? In what order do they occur?
Product definition, description, specification	Are the differences clear?
Version, variant, release, option, model, revision	Are the differences clear?
Product life, lifetime, lifecycle	Are the differences clear?
Prototype, pilot, product	Are the differences clear?
Recycle, dispose, retire, reuse, upgrade, refurbish	Are the differences clear?
Project cost	Which costs are included in the cost of a project? Which overhead costs are included?
Number of parts in a product	Is it clear which parts are being counted? How are duplicate parts counted?
Portfolio Management	Which portfolio is being managed? A Product Portfolio? A Project Portfolio?
Date	When is 11/10/12? Is that October 11, 2012? Is it 10 November 2012? Is it October 12, 2011?

Fig. 4.25 Product and lifecycle mystification

Navigation paths are needed so people can get from one piece of data to related information. There are many relationships between data. Often, they aren't managed.

Definitions and descriptions of options, variants, versions, iterations and alternatives have to be managed carefully.

Each department develops its own jargon. This may be misunderstood by other departments, leading to mystification and confusion (Fig. 4.25) as people try to communicate information about an object that's described and defined in many different ways.

The sheer volume of product data makes it difficult to manage. There can be millions of objects, descriptions, numbers and words of product data to manage.

With all these issues related to product data, it's not surprising that product development and support activities are delayed for many apparently random and minor, but cumulatively significant reasons.

4.3.2 Interaction with Other Activities

Product data is not an island (Fig. 4.26), isolated from the rest of the world. Product data is closely related with other PLM components. It's also influenced by other forces within the company, and outside the company.

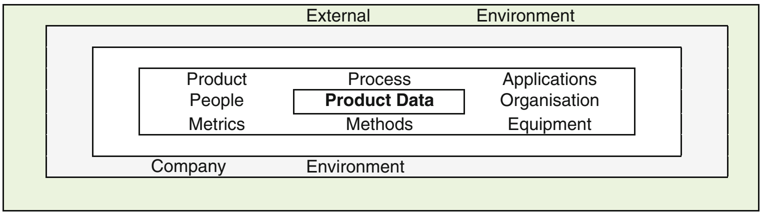


Fig. 4.26 Product data is not an island

Product data is closely related to the other PLM components. A change in product data can lead to changes in the other components. For example, if the precision of a test result has to be increased, the application that creates the data may need to be modified and the application that stores the data may need to be modified. To enable the change in precision, the test method may need to be changed. The description of the process, showing how the data is created and used, will be changed. Users of the data will need to be informed of the changes. The data may be used in a performance indicator, which may need to be adjusted. Downstream users of the data may need to make changes to equipment.

4.3.3 Interaction with Company Initiatives

Most organisations have lots of initiatives running. These initiatives have names such as Document Management, Content Management, Concurrent Engineering, Knowledge Management, Business Intelligence, Global Product Development, Innovation, Corporate Intranet, etc. Product data may be in the scope of many of these.

Each of these initiatives is focused on its own success and tends to see other initiatives as competitors. It's likely they will see the PLM Initiative as a competitor for resources and for successful outcome.

It's useful to identify the other initiatives addressing product data, find out which initiatives may be supportive and which will not. Then work out how to work with all of them.

4.3.4 Generic Challenges and Objectives

The specific product data-related challenges that a particular company faces could come from several sources (Fig. 4.27).

duplicate data	knowledge in heads not documented
confidential data lost	difficulties to exchange data with partners
ownership of data unclear	unreleased versions of data mistakenly used
inability to access legacy data	problems accessing data on old magnetic tapes
multiple overlapping databases	conflicting different copies of the same data
incorrect data sent to a customer	difficulty to manage data at several locations

Fig. 4.27 Potential product data-related challenges for a company

4.3.5 *A Generic Vision for Product Data in PLM*

In a PLM Initiative, most companies will want to develop a PLM Vision, a view of their future PLM environment. The implementation of PLM in different companies will be different. However, the vision for the future is likely to be similar. Some typical contents of a PLM vision for product data are shown below, grouped in six main sections.

4.3.5.1 Clean, Standard, Process-Driven Data

Throughout the product lifecycle, product data is all-important. It's all that people can work with when the product doesn't physically exist in their environment. Product data is a strategic resource. Its management is a key issue. It needs to be available, whenever it's needed, wherever it's needed, by whoever needs it, throughout the product lifecycle. Working closely together, product development team members will use a common, shared vocabulary and standardised data definitions. To save time and money, team members will want to work together using standard processes, standard data and standard applications. They'll also want to work with standard processes, standard data and standard applications with their suppliers, customers, and partners. Without standards, each data interface between different processes, applications and documents is a potential source of errors, adding costs, and slowing down activities. Once industry-standard processes are clear, their data and document requirements can be defined, and document definition, use and exchange agreed. A single common standard template for each document can be introduced across the extended enterprise.

Feedback about the use of one generation of a product helps improve future generations of the product. Information from product use and support will be used in product development.

There'll be a document describing the common, shared vocabulary and standardised product data definitions. There'll be a document describing the documents used to develop and support the product across the lifecycle.

4.3.5.2 Digital Data

All information will be converted to digital form so that it can be used, managed and communicated effectively. In PLM, all product data should be either in a data base or accessed through a data base. Correct and up-to-date digital data about the product portfolio, existing products, and products under development, are needed for short, medium and long-term decision-making. Digital product data will flow smoothly through the lifecycle, and will be available when and where needed.

There'll be documents describing our product data strategy, product data architecture and product data model.

4.3.5.3 Data Management

A Product Data Management (PDM) application will provide people in the product lifecycle with exactly the right information at exactly the right time. Having digital product data under PDM control will help achieve the objectives of improved product development and support. With PDM, it will be much quicker and easier to access, retrieve and reuse product data. The PDM application will manage all data defining and related to the product across the product lifecycle from initial idea to retirement. It will provide controlled access to correct versions and configurations. It will enable tracking of product configurations.

4.3.5.4 Legacy Data

The different types of legacy data will be identified. Policies will be defined for managing them and, where possible, for eliminating them.

4.3.5.5 Data Exchange

A review will be made of the need for different data formats. Where these are found to be necessary, standard approaches will be implemented for data exchange.

4.3.5.6 Progress with Data, Information and Knowledge

Targets for product data are needed to measure the success of PLM deployment.

4.3.5.7 Progress Report

A "progress report" (Fig. 4.28) might be written 5 years after the PLM Initiative is started.

> More than 99.9% of data in use are in digital form. The number of different versions of document templates across sites has been reduced to one for each template. All sites use the same document template for Product Change Management. In 85% of cases, duplicate data (such as duplicate part descriptions) have been eliminated to leave a single clean data element. The target is still 100%.

Fig. 4.28 Reporting progress with product data

4.4 Product Data Activities in the PLM Initiative

A PLM Initiative takes a company from its current PLM situation to a desired future PLM situation (Fig. 3.32). More than 90 % of the PLM Initiatives in which we've been involved have included product data in their scope.

4.4.1 Product Data-Related Projects

In the typical PLM Initiative there are usually many projects related to product data. Some examples are shown in Fig. 4.29. Depending on the Initiative, some of these projects may run independently. Some may run in parallel, or overlap. Others may be linked to Initiative projects related to processes, PLM applications and/or change management.

People in the PLM Initiative who come from different backgrounds may have very different understandings of the terms used in the product data environment. It's helpful to develop a glossary that gives short definitions of the various terms used in discussions about product data. This will help everyone understand the terms and get a common understanding. Some training about product data may be useful for some people in the Initiative as they may never have participated in activities addressing product data.

4.4.2 Product Data Modelling

In most PLM Initiatives there will be a project to model the product data. There are many reasons for this (Fig. 4.30).

develop a product data management strategy	model the current product data
develop a product data management architecture	model the future product data
develop a plan for activities addressing product data	define product data KPIs
develop a Product Data Glossary	restructure product data
provide Product Data training	product data cleansing
improve product data quality	product data migration

Fig. 4.29 Examples of PLM initiative projects related to product data

models are easy to understand	models improve understanding of product data
models require little training	models clarify business needs for product data
models are good communication tools	models are a good sharable description of product data
models clarify product data structure	models allow improvement opportunities to be identified
models are needed for software development	models allow many people in the business to be involved

Fig. 4.30 Reasons for making and using product data models

4.4.2.1 Iterative Approach

An iterative approach is generally taken to the development of a product data model. The main activities are to identify entities, entity attributes, entity relationships and cardinality. It's often helpful to review data models of neighbouring applications as they may contain some of the same entities. The first attempt at making a product data model will probably lack detail and be incorrect. However, it provides a starting point from which further refinement can take place.

4.4.2.2 Involvement in Modelling

Development of models usually involves many people in the PLM Initiative. Involvement in this activity helps them better understand the entities and activities in the product lifecycle. The relationships between entities, activities, processes, documents, applications and people will become clearer. They'll understand the events that link activities, and identify the major management milestones used to control them. Involvement of people at this stage will increase their commitment to the success of the future environment.

4.4.2.3 Characteristics of Modellers and Models

Usually some of the people involved in the modelling activity have a good understanding of a particular modelling technique gained in academic or business courses. They know the rules and try to keep to them. Many people though, haven't been trained to use a particular model. They may not want to keep to any rules. The result is that models are often produced with elements of different techniques, and are only understood by those who produce them.

4.4.3 Product Data Improvement

Unless companies take good care of their product data it will slip into decay. Before long, problems will result. The company will look for solutions. The problems may be of different types. As a result, there may be several targets for product data improvement (Fig. 4.31).

improve the quality of data	standardise data structures
reduce data search time	harmonise data across sites
reduce data duplication and redundancy	reduce maintenance costs
reduce data transfer volumes and time	enable faster software development
reduce interfaces	enable faster project execution

Fig. 4.31 Targets for product data improvement

ensure management support	set improvement targets
identify the strategy for product data improvement	map existing product data with experienced modellers
make the plan for product data improvement	develop future product data models
define ownership, roles and responsibilities	put data models under change management
take a cross-functional approach	maintain the models
involve Subject Matter Experts from all functions	measure the new performance level
define the existing performance level	continuously improve

Fig. 4.32 Success factors for product data improvement

Projects to improve product data may run as part of a PLM Initiative or independently. In either case, they are likely to be challenging. Product data is used by many people. Any changes are likely to upset some of them. Some success factors for projects to improve product data are shown in Fig. 4.32.

4.4.4 Product Data Cleansing

For various reasons (Fig. 4.33), a company may decide to clean up its product data. There may be all sorts of problems with the data. It may be difficult to work with because it's in different formats and has different levels of detail. It may contain errors resulting from uncontrolled data entry or transmission. In different systems, entities may have been defined in different ways. For these and other such reasons, the data is "dirty". Some data may be out-of-date, some redundant, some incomplete, some formatted incorrectly or wrong. Some may be incorrect, out of range, of the wrong data type, have an illegal value, duplicate, contradictory, conflicting, or use the wrong units.

The goal of data cleansing is to clean up the product data and get rid of all the problems. Algorithms, data tables and rules are used to find and correct (or remove) them. Afterwards there should be a clean, consistent database. Some guidelines for data cleansing are shown in Fig. 4.34.

product data is incomplete	input of data was not checked
product data was incorrectly named	product data is duplicated
product data was wrongly structured	there are many copies of the data
product data has wrong relationships	metadata is missing

Fig. 4.33 Typical reasons why product data cleansing is needed

review the product data management strategy	identify instances of dirty data, validate proposed solutions
clarify ownership of data elements	make corrections
investigate the current state of the product data	enrich, where applicable, with missing data
inspect product data to identify data problems	check for duplicates, keeping one
review problems to identify sources	implement barriers to prevent further data degradation
identify impact on business	put in place procedures to ensure data is created correctly
identify potential solutions	implement automation to keep out dirty product data
standardise data as required to enable comparisons	regularly review and clean product data

Fig. 4.34 Guidelines for data cleansing

4.4.5 Product Data Migration

For a variety of reasons (Fig. 4.35), product data sometimes has to be moved ("migrated") from one system to another. The migration usually takes place in several steps. In some PLM Initiatives one of these steps will be to clean the data. In others, where the data is clean, this won't be necessary.

An important step of migration is to plan it in detail and be sure that any sources of potential disaster have been identified. No product data can be lost or unintentionally changed during migration. Acceptance criteria have to be defined so that it will be possible to judge whether the migration has been successful. Any conversion or migration algorithms that will be needed have to be identified and implemented.

Once these steps have been taken, the next step is to extract the product data from its source system. The algorithms can then be applied. Then the data can be loaded into the new system. Usually a verification step comes next. This is followed by an acceptance test. After acceptance, the data can be removed from the source system.

There are several approaches to product data migration. In some cases, a Big Bang (all at once) approach is possible. Sometimes the migration will take place system by system, or database by database. Sometimes the migration will be phased, with different types of data included in each phase. Sometimes a pilot will be run. Guidelines for data migration (Fig. 4.36) will help find the best approach for a particular situation.

implementation of a new system	harmonisation of applications
addition of data from an acquired company	database structure change
hardware upgrade	maintenance
software upgrade	workload balancing

Fig. 4.35 Typical reasons why product data is migrated

clarify the post-migration product data environment	define product data cleansing/conversion/migration rules
review the as-is situation of the product data	document the migration tasks, including data cleansing
define targets, strategy and success criteria for migration	plan the migration
identify all product data to be migrated	start the migration with a small step, involving the SMEs
clarify post-migration approach to maintain quality data	test and validate migrated data from the first step
identify product data owners, SMEs and data migrators	carry out the full migration
define data roles and responsibilities	test and validate migrated product data
train owners, SMEs and migrators as required	review results with owners
define product data cleansing/conversion/migration needs	get sign-off for successful product data migration

Fig. 4.36 Guidelines for data migration

4.5 Learning from Experience

From experience in many Initiatives, lessons can be learned about success factors and potential pitfalls. It's good to be aware of them before starting the Initiative.

4.5.1 From the Trenches

4.5.1.1 Devil in the Details (1)

Once I was involved with the harmonisation of PLM applications after one aerospace company had acquired another. Not surprisingly, the two companies had slightly different product data models for their PDM systems. This led to extra work when the two PDM databases were merged. One example of a difference was in the way they treated a part's material. In one company, the material had been modelled as an attribute of the part. In the other company, the raw material stock (1 inch Ti rod) was modelled as an entity. There was an "is made of" relationship between the part and the material.

4.5.1.2 Devil in the Details (2)

I was asked by the two top managers of a pharmaceuticals company to find out why their Research department hadn't come up with any new proposals for a few months. I showed them the PLM Grid (Fig. 1.5) and asked where they thought the problem might be. One thought that the issue could be in the "People" area. He suggested it might be related to problems with a new manager who'd been hired a few months earlier in March. Apparently he wasn't liked by his research team. The other said that the problem could be in the "Organisation" area. He thought it could be "too much bureaucracy". Apparently, in February the regulators had requested even more documentation about research activities. And this was overloading everybody. My next meeting was with the Development Director. On her PC she showed me the file in which they received proposals for new molecules from the Discovery team. I could see that the latest addition was in February, just before the new research boss was hired. My next meeting was with the new research boss. Actually, it was intended to be with the boss. But it turned out to be with the boss and some of his team members. He apologised for not yet being up to speed with everything, but assured me his team could answer my questions. When I got round to asking about new discoveries, one of the team volunteered to show me the spread-sheet where these were logged. Surprisingly, the file showed new proposals in March, April and May. None of the team knew how the molecules were transferred from the Discovery spread-sheet to the Development file, so an IT person was called in. They promised to have the information by the next day. A few days later I heard that there was an interface program between the Research spread-sheet and the Development file. In March, IT had moved to new versions of many programs, but nobody had updated the interface. Now they'd worked until past midnight to fix it, and Development had the new molecules.

4.5.1.3 Devil in the Details (3)

I worked with the Operations VP of one company to improve the New Product Development process. When we'd finished, he asked me to develop a training program for people who would work in the process. That went well, and he asked me to develop a process to link the activities around new product development projects with the company's annual planning and budget exercise. As soon as the process existed, it was used for that year's planning exercise. After that, he wanted me to complement the product development process with processes through to the end of the product lifecycle. Once that was done, he considered I knew the company well enough to review the Engineering Change Management process. He told me to contact the person responsible for the process.

I arranged a meeting. The person worked in the Document Management Group. His office was in a cellar in a building miles away from the headquarters skyscraper. I told him what I'd been asked to do. He said he didn't understand as he'd made a proposal on the same subject to the Operating Committee. But he hadn't been asked to present it. When he showed it to me I wasn't surprised. From the meetings I'd attended I knew the Committee liked to hear about great new products from highly communicative Product Managers. Not about more paperwork. He seemed offended when I mentioned this. He told me it was a serious issue, and Engineering Changes wasted more money each year than was earned from sales of fairy tale new products. I said I believed him, but the Committee seemed to prefer great packaging and little content to great content and little packaging. He said he'd think about it, but I got the feeling he'd already decided what to do.

When I went back to his cellar the following week, I could hardly get in his office. It was full of cardboard boxes. When I asked what had happened, he grinned and said the boxes were for our presentation at the Operating Committee meeting the following week. "Our presentation?". Yes, we were going to make a presentation about Engineering Change to the Operating Committee. And he explained that a few months back, Marketing had decided to upgrade the corporate image, logo, colours and so on. As a result of which they'd requested a little change to the colour of the machine identification plate. There were several thousand of these plates. People had gone to work on changing all the corresponding documents. When they'd finished and the change was reviewed, the Legal department had told them they weren't allowed to change the colour. So they'd had to change all the documents back to the original colour. I asked if that was what was in the boxes. No, he said, he only had about 10 % of the documents in his office. He'd had to find another place to store the others. For the Committee meeting he'd organised a couple of forklift trucks to bring the boxes into the meeting room. Maybe I didn't look very well, because he told me, “it’s OK, the Operations VP says we can do it”. We did, and the feedback wasn’t “not more paperwork”. It was “fix that process as quickly as you can. We don’t ever want to hear about something like this again”.

4.5.1.4 Devil in the Details (4)

As sometimes happens, a car manufacturer called me in after it had a problem with an important customer. In this case, the customer had been loyal for more than 30 years. But, since receiving the latest model he was very unhappy. Some time back, after he’d seen the brochure in his local showroom, he’d gone home and checked the height of his garage. He’d always had standard 4-door sedans before, but the great new MPV minivan was much taller. The garage height was OK, he’d have about an inch of clearance. He was the first in his neighbourhood to take delivery of the new model. He drove it round for a while so that everyone would see it. Then he went home and parked it in the garage. Except he didn’t. The MPV jammed under the garage roof. It was badly damaged and he had to go to hospital with cervical vertebrae problems. I found the direct cause fairly quickly. He’d picked up the first version of the product brochure in the showroom. Between its publication, and production of the first vehicles, one of which he’d bought, the height had been increased by 2 inches.

4.5.1.5 Devil in the Details (5)

A global company in the transportation industry asked us to help with their data structures. In one country, they had successfully developed a new advanced control system for a customer. Sales teams in six other countries had picked up the concept and sold it, with a few adjustments, in their own countries. The system had over 20,000 components, but only about half had been used in all the systems. The “few adjustments” had usually changed a few thousand parts. Management now wanted to find the best structure. This was expressed as maximum use of standard components, minimum time to propose a new system, and minimum cost of customisation.

This is another illustration of the devil being in the details. The starting point was seven lists of over 20,000 components. What was essential (safety), what were the variables (length of the transport system, its complexity, reliability), what could be in common? What could be in a module, what could be in an interface?

4.5.1.6 Devil in the Details (6)

We were asked by a company making plastic products to carry out a review after their implementation of a PDM system. Apparently users weren’t happy. One of the issues we found was related to the plastic granules used to make many of the company's products. The company knew that granules from one supplier's factory were slightly different from those from the supplier's other factory, and allowed for this in production. The service provider hadn't seen this product characteristic, so hadn't allowed for it in the database.

4.5.1.7 Devil in the Details (7)

Another example of the devil in the details came when a company closed down one site and moved everything to its other site. Until then, the two sites had been fairly, but not totally, independent. For example, they used the same PDM system, but with different data models. One site's data model was built around an 8-digit number for the products that the company made. On the other site, the data model was built around a 10-digit number for the products that the company sold. Years ago, these choices might have been taken in a few minutes or hours. However, after a decade of use, they resulted in man-years of harmonisation effort.

4.5.1.8 Mission-Critical Product Data

I worked with a supplier to the Challenger Space Shuttle mission, and watched the launch on the morning of January 28, 1986. Challenger exploded 73 s after launch. The seven-member crew died. A Presidential Commission investigated the accident. It found the physical cause was the failure of the O-ring pressure seals in the aft field joint of the right Solid Rocket Booster. They weren't certified to fly below 53 °F. At launch time the temperature was 36 °F, and overnight had dropped to 19 °F. The Commission found that, on the eve of the launch, NASA and the Booster builder debated whether to operate the Shuttle in the expected cold weather. The engineers recommended a launch postponement. Under pressure from mid-level managers, they reversed the recommendation and gave the go-ahead to launch.

4.5.1.9 Product Data in Prior Art

Often, when people think of product data they think of the product definition phase of the lifecycle. But there's product data across the lifecycle. And some very important product data exists before the product definition phase. As part of the defence of his client, we were asked by a patent lawyer to find prior art related to a rival's patent claim. Prior art is any information about the idea of a patent that's publicly available before the date of the patent claim. Its existence shows the idea isn't original. It's product data in the imagine phase of the lifecycle. And it can be very valuable.

4.5.1.10 Product Data in the Operating Phase

We saw another example of product data outside the design phase when an accident investigator asked for help. The investigator had identified an unusually high number of scalding accidents with a company's domestic water heaters in a particular neighbourhood. Although the heaters were all from the same manufacturer, they didn't all seem to be the same model. Maybe we could find a common cause? Did these heaters share a common component? We found that the heaters involved in the accidents definitely were different models. We reported this to the investigator, adding that the only commonality we'd seen was that most of the scalding was to the lower legs, but the water heaters were wall-mounted about 5 ft above the floor. That got the investigator thinking. He found that the punishment method of one of the local gangs was to remove a manhole cover and put someone down a steam vent.

4.5.1.11 Unexpected Reaction

A company wasn't happy with the service provider recommended to implement its PDM system. The company complained that the service provider wasn't keeping to plan. The service provider claimed the company kept changing its requirements. We were asked to give a neutral opinion. As soon as we started work, we were told that one of the big issues was electrical multiple-sheet drawings. The company had a special rule for identifying the first sheet and the continuation sheets. Except that, for one customer, there was a different rule for multi-sheet drawings. And, implicitly, there was another rule as some customers refused to accept multi-sheet drawings.

We looked at the data model to see how multi-sheet drawings were going to be managed. We found the service provider's system architect had proposed a data model from a company in an industry sector that didn't have multi-sheet drawings. From the names of the entities in the model, we could even work out the name of the company. The service provider fixed the problem by providing a senior system architect who proposed a data model that fitted the company's requirements.

4.5.1.12 Data Review (1)

Figure 4.37 comes from the report of a review of the data received at a company's manufacturing site ("The Site") from the development engineering sites.

4.5.1.13 Data Review (2)

Figure 4.38 comes from the report of a review of product data throughout the product lifecycle. The subjects to be addressed were grouped into 20 categories.

Subject	*Statement*
Accessibility	Data can be difficult to access as there is not a single database for all information. In the extreme case, data must be accessed in five applications, as well as on paper.
Accuracy	Accuracy of data is not known. There is no indication as to whether the information is a rough guess, or 100% accurate.
Creation	The Site creates data using the same applications as the development engineering sites. However, it has its own templates.
Change	The Site may receive data, review and redline it, and send it back. As there is not a common change system across all sites, the next version that The Site receives may take no account of the redline.
Common Definition	Across the sites, there are not common definitions of documents and data elements.
Communication	There are difficulties communicating with design engineering. Frequently, e-mails are not answered. Telephone calls are not always returned promptly.
Compatibility	Data is compatible. The Site uses the same applications (at the same level) as the development engineering sites.
Completeness	Data packages received by The Site are said to be frequently incomplete. A quick review of the most recently received packages showed that about half were incomplete.
Consistency	Data created by the development engineering sites is not consistent. Each has its own approach. Also, with the exception of one development engineering site, data received from each of the other sites is not internally consistent. Different people on these sites use different names, relationships and structures.
Cost	A single hourly rate is applied to everything done by The Site. There is no differentiation by task.
Security	There is no control over data taken out of The Site. Also, any data can be sent anywhere by e-mail.
Timing	Data received by The Site from the development engineering sites comes in any order and at any time.
Usability	Data received by The Site from the development engineering sites frequently needs to be reformatted before it can be used. A quick review of the most recently received data showed that about 20% needed to be reformatted.
Value	There is no figure for the value of The Site's data.
Version Management	The Site keeps and manages all versions of data that it receives. The development engineering sites use different versioning schemes, complicating The Site's version management activities. For some data elements, it's unclear which version is the Master version.

Fig. 4.37 Review of data at the manufacturing interface

The relative weight (1 = low, 10 = high) of each category was defined. For each category, the current performance (P = Poor, F = Fair, G = Good, V = Very Good, E = Excellent) was determined.

4.5.2 Product Data Improvement Approach

We've found that many companies want to take a fast, lean approach to improvement of their product data. We take the following eight-step approach to product data improvement (Fig. 4.39).

4.5.2.1 As-Is

We get a cross-functional group of people from the company to document the use, flow and structure of product data throughout the lifecycle. We start off by asking

Category	*Weight*	*P*	*F*	*G*	*V*	*E*
Data across lifecycle	9			x		
Data archival	3				x	
Data cleanliness	8	x				
Data costs and value	3		x			
Data creation and change	7			x		
Data definition and model	10		x			
Data, digital data	5				x	
Data exchange (internal and external)	6			x		
Data feedback	3	x				
Data, legacy data	4				x	
Data management (applications)	8				x	
Data management (human resources)	5			x		
Data management (processes)	8			x		
Data metrics	4		x			
Data objects completeness	9		x			
Data ownership and responsibilities	10		x			
Data re-use	4		x			
Data security	5			x		
Data use everyday	9			x		
Data users	7		x			

Fig. 4.38 Review of product data

1	Prepare	Write down the scope and objectives. Plan the expected activities, taking care to include activities such as planning, reporting, interviewing, documenting, presenting, communicating and sustaining
2	As-is	Document the as-is situation of data. Document its users and its use, flows, types and structures. Document objectives, performance measures, problems, requirements. Document PDM applications. Document other PLM applications that manage product data. Identify data-related problems and weaknesses. Identify the causes
3	To-be	Define 3 or 4 options for the future improved situation. SWOT to get the best
4	Strategy	Identify several potential strategies. SWOT to get the best strategy
5	Plan	Develop an implementation plan for an initial project, and for further rollout phases
6	Communicate	Communicate a compelling case for improvement
7	Implement	Start small, get some success. Check progress against targets. Communicate success
8	Sustain	When the initial project ends, start previously planned follow-on activities

Fig. 4.39 Eight step approach to product data improvement

them to identify the types of entities in the PLM environment that are represented by the product data. This usually leads to a list such as that shown in Fig. 4.40.

Then we ask them to identify potential locations of the data describing these entities. This usually leads to a list such as that in Fig. 4.41.

Then we get the team to list, for example, all the paper documents in the PLM environment. Excel is an ideal support tool for this activity. Different types of information about each document can be entered column by column. Examples are

products	processes	documents
components	people	equipment

Fig. 4.40 Examples of entities in the PLM environment

paper documents	databases	interfaces	desks
electronic documents	metadata descriptions	directories	legacy systems
processes	applications	files	archives

Fig. 4.41 Locations of data

owner, type, title, and creation date. The potential states of data can be defined. They may include in-process, in-review, released, and obsolete.

The team then makes a list of other documents in the product lifecycle. The different types of document are described briefly and their characteristics and volumes noted. The different types of data are described briefly, with their characteristics and their volumes being noted. For each data type, and each document type, the most important attributes are documented. Transition rules between different states of data are described.

Data flow diagrams are made to show how product data flows throughout the product lifecycle. The different structures of product data, such as Bills of Materials and parts lists, are described, as are other associations such as product/drawing relationships.

Owners and users of product data are identified. Access needs, and the rights of users and groups of users, are described.

Shared and redundant data are described. Data standards and templates are described. Any data security and data integrity issues are described.

The team makes a picture of the current organisation of the company, from the point of view of product data. This shows the number of users and their locations, both geographically and functionally, and the way they store and communicate information. It shows where data is created, modified and stored, and how it's communicated and shared.

We get the team to create a simple data model in PowerPoint. This shows how entities such as parts and documents are related to each other. And how they're related to the product that's sold to the customer, and its packaging.

4.5.2.2 Towards To-Be

In addition to documenting, understanding and detailing the existing data and documents, we get the cross-functional group to describe the problems they face with product data. As they continue to document the as-is structure and document the problems they face, they can draw up a picture of things that have gone wrong, and things that should be avoided in future (Fig. 4.42).

Overproduction	Creating product data/documents that will never be used Recreating product data/documents that will never be used Recreating product data/documents that exist elsewhere Duplicating existing product data Manually re-entering existing data
Excess transportation	Pushing information to everyone on a list, even if they don't need it Unnecessary transportation of documents around the shop floor Unnecessary transportation of product data between computers Excessive use of cc: on e-mails with long attachments
Over-processing	Too much detail in a report Too much detail on a design drawing Creating data that has no effect on the product
Inventory	Building an inventory of unused information Creating speculative part numbers that are never used Piling up drawings waiting to be signed Making stacks of reports waiting to be read Creating data just-in-case
Movement	Walking around the office looking for drawings and other information Searching for data in computer systems Travelling to a customer site to collect data
Defects	Reports that contain errors Mistakes on drawings Missing fields in data records Incorrect numbers and incomplete information Erroneous product data model Erroneous data exchange/translation applications Erroneous interfaces Incorrect relationships in an entity-relationship model
Waiting	Waiting for sign-offs Waiting to read a report Waiting for a drawing that is in a bottleneck Waiting due to serial, rather than parallel,flow

Fig. 4.42 Examples of product data waste to be avoided

4.5.2.3 To-Be

When the as-is situation of data has been understood, the as-is data and its problems are documented and analysed. The objectives for the future situation are documented. The results of the data sub-project up to this point are presented to project sponsors. This will help keep them informed of progress. It will also give them an opportunity to give their feedback on the findings.

We then get the team to address improvement of the as-is situation. Many types of improvement can be proposed and evaluated. For example, the team can make proposals to improve the quality of product data. Suggestions can be made to improve the activities addressing product data. There can be suggestions to clean the data, removing redundant data and correcting incorrect data. Other improvements can be suggested, including the introduction of new technologies, such as a PDM application, and taking advantage of best practices. We get the team to suggest KPIs (Fig. 4.43).

The options for improvement are investigated and compared by the team. Their suggestions for the future situation are documented and presented to management.

number of different data types	% of data with no owner
volumes of data of each type	time spent looking for data
number of documents of each type created annually	number of times that key data is recreated
number of documents of each type under modification	level of data reuse
% of data on electronic media	quality level of data

Fig. 4.43 Examples of potential KPIs

4.5.2.4 To-Be Data Model

We get the team to develop the basics of a data model for the future situation. It doesn't take long to develop such a basic model. The intention is only to highlight the main entities and their relationships, and to identify the main attributes for each entity. We don't expect the team to develop a complete, fully-detailed data model. This can be done later with the involvement of other people who have the corresponding specific skills and experience.

4.5.2.5 Benefits

Documenting the as-is situation shows some of the problems with data. In one case, several data items were found to have an annual decay rate of over 40 %. In another case, merging data from three sources, more than 20 % of documents were found to have duplicates. About 11 % of data had some kind of inaccuracy. In another case, over 15 % of relationships showed some kind of inaccuracy. Benefits achieved in sub-projects to improve product data and product data management are impressive. Performance measures such as data quality and reuse of data have been improved by more than 30 %. Other examples of benefits achieved include a reduction in data entry cost of more than 10 %, and a reduction in data management costs of 15 %.

4.5.3 Pitfalls of Product Data Modelling

Product data modelling is a frequent activity in PLM Initiatives. From experience with many companies, lessons can be learned. There are many potential pitfalls in product data modelling (Fig. 4.44). It's good to be aware of them before falling in.

not involving business stakeholders	not communicating models outside the modelling group
not involving Subject Matter Experts	not reviewing models with business managers
not ensuring the models make business sense	not questioning data assertions of business participants
not involving participants across the lifecycle	not defining rules for modelling (symbols, naming, etc.)
not being 100% clear when product data modelling	not understanding business rationale for product data
not laying out the model in an easy-to-read format	not setting clear objectives for data modelling
not having a clear, agreed plan for product modelling	not defining the scope of the product data modelling
not modelling with experienced modellers	not seeing models as living, evolving descriptions
not modelling consistently to the same level of detail	not giving ownership of data models to the business
not putting data models under change management	not mentioning current alternatives (e.g., names, status)

Fig. 4.44 Pitfalls of product data modelling

4.5.4 Top Management Role with Product Data

4.5.4.1 Under Control

Management needs to get product data under control. Product data lies at the heart of the product lifecycle in today's computerised, information-based environment, yet few companies have it under tight control. Product data is scattered across many locations. It's on paper, clouds, microfilm, aperture cards, USB flash drives and computers. People keep several copies of data, and have different versions of what should be the same data. As companies invest in more and more IS technology, it becomes even more difficult to maintain control of the company's product data, a valuable company resource. It becomes more difficult for companies, that must comply with legal requirements on traceability, to maintain audit trails so that they can track back to the source of any product problems. Many companies need to be able to provide data about the path of a particular product/ingredient or batch of products/ingredients from their origin, through intermediate steps, to the customer. It becomes increasingly difficult for companies to know which is the "master" version of product data. Is it a computer-based model or a drawing? Is it the scanned image of a document, or the document itself? As more data is shared with suppliers, similar questions arise about the master. Procedures have to be defined to show how the two companies can make changes.

4.5.4.2 High Quality

Management needs to make sure that the product data in use is of high quality. Without reliable, timely and accurate data, managers and users can't work efficiently. It's difficult to run quality checks on data moving invisibly round networks, so quality has to be built in. This can only be done through the right procedures and a company culture that penalises poor quality work. Error creation and propagation must be prevented. It's only too easy for a user to introduce an error into product data. Once the error is in though, it can be difficult to find, and it can be even more difficult to remove its effects.

4.5.4.3 Complete

Management needs to ensure that its approach to product data is complete. It should address both existing data and data to be created in the future. The use and management of product data isn't a green field activity, and shouldn't be treated as one. Most companies have a vast amount of information tied up in existing data. One of the major challenges is to marry the ability to meet current and future needs effectively with the capability to reuse existing product data.

4.5.4.4 Secure

Management needs to make sure that product data is secure. Individual users may be worried that a colleague could unintentionally erase their work. Companies may be worried that access rights granted to trusted suppliers might somehow be discovered by unscrupulous competitors. Major multinationals transmitting design information by satellite between sites in different continents wonder how secure their product data is. Management must ensure that confidential and proprietary information is protected from unauthorised access. Product data is valuable Intellectual Property.

4.5.4.5 Available

Management needs to make product data available to users when they need it, otherwise valuable time will be lost. If management really wants to reduce lead times, it will have to cut the waste out of processes in which product data is used. Administrative paper-shuffling will have to be abolished. Lean techniques, successfully applied on the shop floor, will have to be applied throughout the product lifecycle. Product data must flow smoothly through the organisation. Old habits of spending hours, or days, looking for data will have to disappear. The product data made available will of course, have to be the right data, otherwise more time will be lost until the correct version is found.

4.5.4.6 Strategic Asset in the Digital Company

There's a trend towards operations becoming more information-intensive, and a corresponding push to use information-driven processes to support overall business activities. Another trend is the increased computerisation of product development and support activities and the resulting sharp growth in the volume and availability of digital product data. Together, these make product data a high-value company asset, requiring top management attention. This leads to awareness of the importance of product data management, and the advantages that can be achieved through improved control of product lifecycle activities. Information security, privacy and back-up are key issues.

4.5.4.7 Cross-Functional

Product data is used and reused by many of the organisational entities within the company. The approach to its overall management has to be cross-functional. Attempts made by individual departments (such as design engineering) to create or impose order will be frustrated by other departments (such as manufacturing engineering) that may feel threatened by such moves or feel it necessary to assert their independence. If this were to happen, the gains expected from an integrated approach would fail to appear. Management needs to make product data available throughout the product lifecycle. Product data belongs to the product, not to individual departments.

4.5.4.8 Reusable

Management needs to make sure that product data is reused, and that it's allowed to evolve. It takes a lot of time and money to create high-quality product data. It costs much less time and money to use existing product data. Management needs to ensure that once product data has been created it is reused in next-generation and other products. There's no point in continually reinventing the wheel, yet products need to be improved so they continue to meet customer requirements. Reuse of information was claimed to be one of the major benefits of use of CAD, but in practice there has been less reuse than expected. The reason has been the difficulty for users, even if they are aware of suitable existing product data, to find this data. It may be somewhere on the CAD system, or in somebody's drawer, or somewhere in a central drawing store. Few users are prepared to spend hours, or even days, hunting for old data. Instead, they take a clean sheet, or screen, and develop an equivalent.

Chapter 5
Information Systems in the PLM Environment

5.1 This Chapter

5.1.1 Objective

The objective of this chapter is to provide an introduction to application software in the PLM environment. The chapter aims to give a basic understanding of PLM applications and related activities. It will help readers working in PLM Initiatives to participate in activities related to PLM applications. The chapter also aims to give students who are studying PLM a basic understanding of the application software components of a company's PLM environment.

5.1.2 Content

The first part of the chapter gives examples of PLM applications and shows why they are relevant in a PLM Initiative. The management of PLM applications in the twentieth century and in the twenty-first century is described briefly. The tools used to represent applications are explained.

The second part of the chapter addresses the situation of PLM applications in a typical company. Application issues are described. Typical challenges are outlined. A brief Vision is given of applications in the future PLM environment.

The third and fourth parts of the chapter address some of the activities in a PLM Initiative that are related to applications. These include application status review, application harmonisation and PDM system selection.

The final part of the chapter builds on experience of working with PLM applications with many companies. Lessons learned are shared. Guidelines and potential pitfalls of application selection and implementation are given. Top management's role with PLM applications is addressed.

J. Stark, *Product Lifecycle Management*, Decision Engineering,
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5.1.2.1 Skills

Students in classes for which this book has been assigned will gain, from this chapter, a basic understanding of applications in the PLM environment. They'll learn about PLM applications and see why they're important. They'll learn how applications are documented. They'll learn about the problems and opportunities with applications in the PLM environment of a typical company. They'll be able to describe the typical activities of an application-related sub-project in a PLM Initiative. And they'll be aware of some companies' experience with application-related sub-projects in PLM Initiatives. As a result, they'll be able to explain, communicate and discuss PLM applications.

5.1.3 Definitions

5.1.3.1 PLM Applications

A PLM Application is a computer program that is used to support a particular activity in the PLM environment. For example, a Computer Aided Design (CAD) application is used to support the product design activity.

5.1.3.2 PDM System

Product data management is the activity of managing product data. A Product Data Management (PDM) system is a computer system, an application, which manages product data. A PDM system is a very specific type of PLM application. It has the sole purpose of managing product data.

5.1.4 Relevance of Applications in PLM

The PDM system and the other PLM applications are among the main components on the PLM Grid (Fig. 1.5).

5.1.4.1 Relevance of PLM Applications

Without PLM applications, it's unlikely that so many complex and precise products could be developed, produced and supported throughout the world. The characteristics of PLM applications (Fig. 5.1) enable the people who use them to achieve performance levels that would be impossible to achieve by manual means alone.

calculate faster	work longer hours
calculate more reliably	do repetitive work better
calculate more precisely	work at lower cost
are always present	work with large quantities of data

Fig. 5.1 Characteristics of PLM applications

5.1.4.2 Relevance of PDM Systems

A PDM system is one of the most important components of PLM. It can manage all the product data created and used throughout the product lifecycle. It can provide exactly the right information at exactly the right time. Throughout the product lifecycle, product data is all-important. The PDM system gets this strategic resource under control, making it available, whenever it's needed, wherever it's needed, by whoever needs it, throughout the product lifecycle.

Whatever the PLM Strategy that's chosen, it's probable that a PDM system will be a major constituent. PDM gets product data under control, and, unless the product data in the product lifecycle is under control, it will be difficult to get the product under control.

PDM systems provide support, in the complex environment of PLM, to the many activities of the lifecycle such as design, sign-off, the sharing of data between multiple users, the tracking of engineering change orders, the management of design alternatives, and the control of product configurations.

PDM systems can be looked at from two viewpoints. Firstly, they alleviate some of the problems that occur in the product development and support environment. Secondly, they pro-actively and positively impact operations across the product lifecycle. Although these reasons can be treated separately, in practice, they're closely related. Reasons in the first class address the resolution of existing problems. Reasons in the second class go one step further, and address the potential for further improvement. The reasons can be grouped into eleven categories. In each category, most of the reasons can be related both to the resolution of current problems and to pro-active improvement of activities across the product lifecycle. The eleven categories, and examples of benefits in each category, are shown in Fig. 5.2.

5.2 Introduction to PLM Applications

5.2.1 PLM Applications in the Product Lifecycle

There are many applications in the PLM environment. More than fifty different classes (groups) of applications are mentioned in this chapter. Within some of these groups of applications, more than one hundred different applications are provided by different application vendors. In total, there are thousands of different applications in the PLM environment. To make it easier to work with them, it's useful to

Benefit Category	*Example of Benefit*
Information Management	provide a single, controlled vault for product information
	maintain different views of information structure
	provide faster access to data
	manage configurations
Re-use of Information	make available existing designs for use in new products
	reduce duplicate data entry
Workflow Management	make sure the most appropriate process is followed
	improve distribution of work
	ensure procedures are followed
Engineering Change Management	speed up Engineering Change distribution, review and approval
	provide status information on engineering changes
Business Performance Improvement	improve product quality
	reduce overhead costs
Business Problem Resolution	reduce scrap
	reduce product liability costs
Functional Performance Improvement	increase engineering productivity
	reduce inventory
	develop better cost estimates
Product Development Management	improve project co-ordination
	increase product development schedule reliability
	provide high-quality management information
Product Development Automation	automate the sign-off process
	automate the transfer of data between applications
IS Effectiveness Improvement	integrate Islands of Automation
	link data bases together
	remove unnecessary systems
Product Development Infrastructure	support product development practices and applications
	distribute data and documents electronically

Fig. 5.2 Eleven categories of benefits of PDM systems

structure them in a manageable way. Applications can be grouped in many different ways. For example, they can be grouped by their type. Figure 5.3 shows PLM applications in 13 groups.

5.2.2 Generic and Specific PLM Applications

PLM applications can also be categorised as generic applications or specific applications.

Generic applications (Fig. 5.4) are applicable to all kinds of companies, all types of products, and all types of user within those companies. They have functionality that will be used throughout the lifecycle. On the other hand, specific PLM applications have functionality that's only needed by a few people in a company.

For example, it will be seen that the first application in the list of generic applications, "data management", is an application which is needed by a design engineer in the automotive industry, but also by a project manager in the pharmaceutical industry. They both have enormous amounts of data to manage. Similarly, the fifth item in the list, "collaboration management", is applicable in any situation where people in different locations are working together.

Idea Management applications. These enable gathering and evaluation of ideas in a structured fashion, and the selection and management of the best ideas
CAE/CAD/CAM applications. The focus in this group is on defining, analysing and simulating product, service and process definition data. Functionality of this type may be found in applications such as CAD, MCAD, ECAD, Electronic Design Automation (EDA), geometric modelling, CAM, C APP, Rapid Prototyping, CAE, DFM, DFA, Software Engineering, NC programming, BOM, routing definition, plastic behaviour analysis, Factory Simulation, technical publishing, and parts library applications. These applications are used in discrete manufacturin g to create the right product and process definition data. In process manufacturing, menu management and recipe management applications have an equivalent role
PDM technologies. The focus here is on managing product, service and process definition data th roughout the product lifecycle. Functionality of this type may be found in applications such as Engineering Document Management, Engineering Data Management, Product Data Management, Technical Document Management, Knowledge Management, Configuration Management, Enterprise Content Management, Regulatory Management and Quality Management applications
Visualisation/Viewing. The focus here is on visualising, viewing and printing product and process definition data. This group includes technologies such as Digital Mock Up and viewers
Collaboration software. The focus here is on applications that allow people at different locations, or in different organisations, to work together over the Web with the same product and process definition data. Collaboration software technologies include e-mail, electronic whiteboards, discussion groups, chat rooms, intranets, extranets, shared project spaces, portals, vortals and project directories
Data exchange and interoperability applications. The focus here is on applications that allow product and process definition data to be transferred from one format, that's usable in one application, to another format that's usable in another application
Customer-oriented applications. The focus here is on capturing product and process definition data from customers, and presenting product and process definition data to customers. Customer-oriented technologies include applications for presenting product catalogues to customers, and applications for capturing customers' needs, requirements, feedback, orders and complaints
Supplier-oriented applications. The focus here is on capturing product and process definition data from suppliers and presenting product and process definition data to suppliers. Supplier-oriented technologies include RFQ applications, CSM applications, strategic sourcing and auctions
Process definition and management. The focus is the definition and management of processes and workflows across the product lifecycle. These include the product development process, release management, and the Engineering Change Management process
Project and program management. The focus is the definition and management of projects addressing activities in the various parts of the product lifecycle
Portfolio Management. The focus is the management of the portfolio of products, and the portfolio of projects to develop new products and modify existing products
Regulatory/Standards/Compliance Management applications.
Integration. The Integration group includes both integration between PLM applications, and integration between a PLM application and another application such as a CRM, ERP or SCM application

Fig. 5.3 Thirteen types of PLM applications

Data Management / Document Management	Visualisation
Part Management / Product Management	Integration
Process Management / Workflow Management	Infrastructure Management
Program Management / Project Management	Product Idea Management
Collaboration Management	Product Feedback Management

Fig. 5.4 Generic PLM applications

Often, all the generic applications are needed for most people working in product-related activities. That isn't the case for the applications in the other category (Fig. 5.5). These are much more specific to a particular context. This category contains more specialised applications that are needed by particular people, departments, functions or industries.

The first item in the list of specific PLM applications, "Product Portfolio Management", has very specific functionality that's only needed by a few people in a company. Similarly "Collaborative Product Definition Management" will have

Product Portfolio Management	Supplier and Sourcing Management
Idea Generation Management	Manufacturing Management
Requirements Management	Maintenance Management
Specifications Management	Compliance Management
Collaborative Product Definition Management	Intellectual Property Management

Fig. 5.5 Specific PLM applications

functionality specific to the needs of people who define the product. Generic and specific PLM applications are detailed in the following sections.

5.2.3 Generic PLM Applications

Generic PLM applications (Fig. 5.4) are those that are applicable to all kinds of companies, all types of products, and all types of user within those companies.

5.2.3.1 Data Management/Document Management

These applications enable a company to store and make available data (documents/drawings/files) throughout the entire product lifecycle in a controlled-access secure distributed environment. They enable activities such as version management, revision control, classification, search, analysis and reporting.

5.2.3.2 Part Management/Product Management/Configuration Management

These applications enable a company to manage products, product structures and product attributes throughout the entire product lifecycle in a controlled-access secure distributed environment. They enable activities such as version management, revision control, classification, search, analysis and reporting. They enable improved reuse of designs, parts and modules.

5.2.3.3 Process Management/Workflow Management

These applications enable a company to map business processes, to define and automate simple workflows (such as document release workflows, and the change management workflow) and ensure compliance with requirements from organisations such as the FDA and the ISO. Templates enable common, repeatable processes. Workflow management includes routing templates, paths, lists, logic and rules. It can also include notification management.

5.2.3.4 Program Management/Project Management

These applications enable a company to plan, manage and control projects and programs. They enable stage, gate, milestone, and deliverable control. They provide visibility into a project's status in terms of progress and costs. They show interdependencies such as those among project resources and intermediate deliverables. These applications provide a range of display options such as dashboards, cockpit charts, pie charts and graphs.

5.2.3.5 Collaboration Management

These applications enable geographically-dispersed teams and individuals to work together in a secure, structured, virtual working environment using up-to-date product data. They include a wide range of functionality (Fig. 5.6).

5.2.3.6 Visualisation

These applications provide viewing, visualisation and virtual mock-up capabilities.

5.2.3.7 Integration

These applications enable exchange of product information between PLM applications (for example, between a CAD application and a CAE application). They also enable exchange of product information between PLM applications and other enterprise applications such as ERP and CRM.

5.2.3.8 Infrastructure Management

These applications manage services of infrastructure such as networks, databases, and servers.

calendars	schedules	e-mail	messaging
tweeting	electronic whiteboards	discussion groups	virtual meeting sites
web conferencing	videoconferencing	audio conferencing	collaborative blogging
collaborative co-authoring	chat rooms	intranets	shared project spaces
portals	vortals	project directories	social networks

Fig. 5.6 Examples of collaboration management tools

5.2.3.9 Idea Management

These applications enable product ideas to be captured and analysed, appropriate actions to be initiated, and progress to be tracked.

5.2.3.10 Product Feedback Management

These applications enable customer feedback about the product to be captured, analysed and made available where needed.

5.2.4 Specific PLM Applications

Compared to the generic PLM applications, the specific applications (Fig. 5.5) are much more specific to a particular context. This group contains more specialised applications that are needed by particular people, departments, functions and industries.

5.2.4.1 Product Portfolio Management

These applications enable review, analysis, simulation, and valuation of a company's Product Portfolio of existing products integrated with the pipeline of development projects. They show estimates of sales and reuse, and show the effects of decisions such as introducing new technologies, making acquisitions and launching joint ventures. They support the analysis of risks/rewards for different scenarios. They enable tracking and analysis of product costs against target costs and profit. These applications provide a range of display options, dashboards, cockpit charts, pie charts and graphs, with possibilities for rolling up, filtering, and grouping information to meet various objectives.

5.2.4.2 Idea Generation Management

These applications enable systematic management of the generation of ideas for new and improved products.

5.2.4.3 Requirements and Specifications Management

These applications enable a company to systematically gather, analyse, communicate and manage product requirements describing market and customer needs. They enable a company to systematically manage and standardise product specifications.

5.2.4.4 Collaborative Product Definition Management

These applications enable the definition of products by people and teams from different companies working at different locations.

5.2.4.5 Supplier and Sourcing Management

These applications enable purchasing teams to collaborate with other team members and external suppliers for various activities such as reviewing, selecting, and purchasing custom and/or standard parts. They support qualification of new suppliers and tracking of supplier performance. They enable early involvement of suppliers, giving them real-time access to relevant product information. They enable product quality planning and use of Quality Templates. They enable the purchasing process to be streamlined, and prevent over-limit purchases.

5.2.4.6 Manufacturing Management

These applications enable realisation teams to simulate, optimise and define the realisation process and better understand the relationships between product, plant, and manufacturing processes.

5.2.4.7 Maintenance Management

These applications enable customer support and maintenance teams to optimise processes, get better customer feedback, carry out activities more effectively, and better manage part and equipment inventories.

5.2.4.8 Compliance Management

These applications enable deployment and management of business processes complying with requirements of organisations such as the ISO and the FDA for the development, production, use and end-of-life of a product.

5.2.4.9 Intellectual Property Management

These applications enable the valuation and management of the intellectual property represented by a company's products and related services.

5.2.5 The PDM System: A Special Application

A PDM system is a very specific type of PLM application. Its primary purpose is to manage product data. There's a huge amount of product data in the PLM environment and it's very difficult to manage. The PDM system is used to keep all this product data under control. PDM systems are very important. As they manage product data, they're positioned just above product data on the PLM Grid (Fig. 1.5).

PDM systems range from simple, off-the-shelf packages with basic functionality to complex tailorable systems with wide-ranging functionality that can be further developed to exactly fit a company's requirements.

A PDM system has eight main components (Fig. 5.7). In different PDM systems, the functionality corresponding to these components may be distributed differently between different modules. Sometimes some of the components aren't present. And, in different PDM systems, the components may have different names. As a result, these eight components aren't always easy to see when looking at a PDM system.

The first component is the Information Warehouse (or Vault). That's where product data is stored. The second component, the Information Warehouse Manager, controls and manages the data in the Information Warehouse. It's responsible for such issues as data access, storage and recall, information security and integrity, concurrent use of data, and archival and recovery. It provides traceability of all actions taken on data.

The PDM system requires a basic infrastructure of a networked IT environment. This third component usually includes computer and communications hardware and software, a range of graphics terminals, printers, plotters, storage and other devices.

The fourth component of the system is the System Administration Manager. This is used to set up and maintain the configuration of the PDM system, and to assign and modify access rights.

Users and other applications access the PDM system through the fifth component, the Interface Module. This supports user queries, menu-driven and forms-driven input, and report generation. It also provides interfaces for applications such as CAD and ERP.

The structure of the information and workflows to be managed by the PDM system is defined by the Product and Workflow Structure Definition Module.

Once initiated, a workflow needs to be kept under control. This is the task of the seventh component, the Workflow Control Module. It controls and coordinates workflow steps. It can manage, for example, the engineering change workflow.

Information Warehouse	Interface Module
Information Warehouse Manager	Product And Workflow Structure Definition Module
Infrastructure	Workflow Control Module
System Administration Manager	Information Management Module

Fig. 5.7 Components of a PDM system

The exact structure of all products and information in the system is maintained by the Information Management Module.

5.2.5.1 PDM Systems in the Early 21st Century

PDM systems should manage product data across the lifecycle. However, in the early twenty-first century, they often only manage a part of a company's product data. Usually this is product data created in product development applications. Other product data is frequently managed by other applications (Fig. 5.8).

5.2.6 Organising the Applications

5.2.6.1 Departmental World

For most of the twentieth century, companies were mainly organised by functional departments such as Marketing, Engineering, Manufacturing and After-Sales. Each department was assigned some of the company's activities. People were assigned to a department. Then, for example, people in Engineering worked the best way to meet Engineering's objectives. They wrote or bought whatever IS applications were best for Engineering. They took IS decisions on a departmental basis, with departmental benefits being the most important criteria. Meanwhile, people in Manufacturing worked the best way to meet Manufacturing's objectives. They also wrote or bought whatever IS applications were best for the activities of their department. The people in Marketing took a similar approach. They also developed or bought whatever applications suited them best.

One result of this was that, after a while, the company had many separate Islands of Automation (Fig. 5.9), each with its own functionality, features and files. There was a lot of wasteful duplication of functionality with, for example, each application having its own user interface and data management functionality.

Product data						
.... examples		Ideas Proposals Requirements Cost estimates Profit estimates Prototypes	Detailed product and process specifications	Test data, analysis data	Manufacturing data, process plans, MBOMS	Field data, complaints
.... created by ..		Word processing, spread-sheet	CAD, recipe development applications	CAE, Test	MRP2	Word processing, spread-sheet
.... managed ..		in files	by PDM	in files	by ERP	in files

Fig. 5.8 Examples of product data managed by the PDM system and by other applications

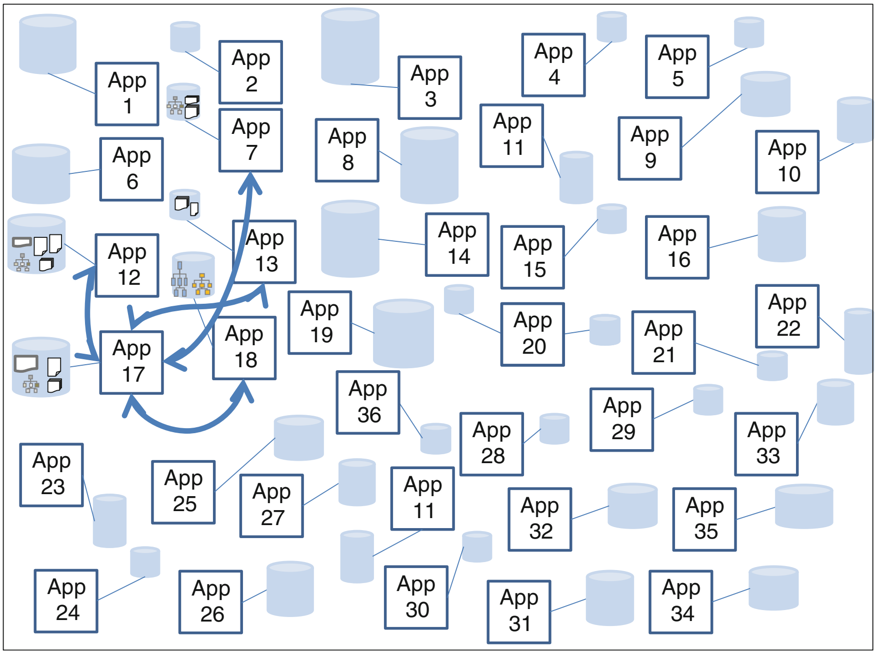

Fig. 5.9 Many applications, interfaces and files in the departmental world

Another result was that that, after a while, there were many interfaces between applications. Some were between applications in the same department. Others were between applications in different departments. In Fig. 5.9, Application 17 is only connected to 4 other applications (7, 12, 13, 18) but has 8 interfaces. The number of interfaces grows quickly. With n applications the number of interfaces is n(n−1). It took a lot of time and effort to build and maintain all the interfaces.

Another issue arose when a new version of an application was delivered. The department wanted its benefits as soon as possible, so implemented it as soon as possible. But the other departments didn't know about this, and were surprised by the effects. They wasted their time understanding the change. And the new version might need changes in an interface, or even another application. This all wasted time and money.

The people taking decisions about IS in each department were specialists in their functional area. For example, in Engineering, people knew about Engineering. However, they hadn't been trained in IS. They were enthusiastic IS amateurs. As they were amateurs, they didn't always do house-keeping tasks such as documenting the software they wrote, making back-ups, documenting working procedures, or defining clear rules for versions and iterations. As a result, more time and money was wasted.

The IS Department was a functional department. Like all functional departments it decided how to do its job without consulting other departments. So, for example, IS mandated that everyone had to work on a mainframe computer. Or that everybody should use computers from a certain vendor. And like the other functional departments, IS people used jargon that nobody else understood.

5.2.6.2 Enterprise World

By the end of the twentieth century many changes were affecting companies. They were under increased competitive pressure to improve products, reduce costs and reduce time to market. The departmental approach wasn't helping. It was inefficient and wasted time and money. Going global created even more problems as companies expanded by acquisitions on other continents. Even after acquisition of two other companies, the application environment became very complex, with duplicate applications and functionality across sites (Fig. 5.10). There was a high rate of technological change. The Web emerged. It became more and more difficult for amateurs to survive.

The departmental approach broke down. An enterprise approach was taken. IS became a corporate function. IS was seen as a company resource, a support function. Instead of doing what it wanted to, IS was told to serve the business and help others to meet their objectives. IS professionals were hired. Instead of developing applications, IS preferred to acquire software packages. Instead of

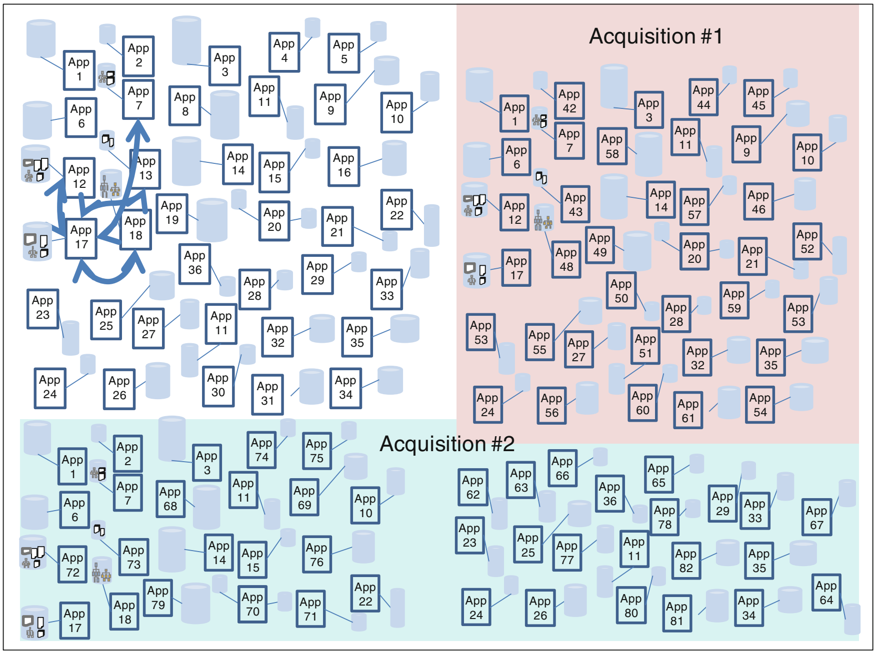

Fig. 5.10 Acquisitions led to even more overlap and duplication

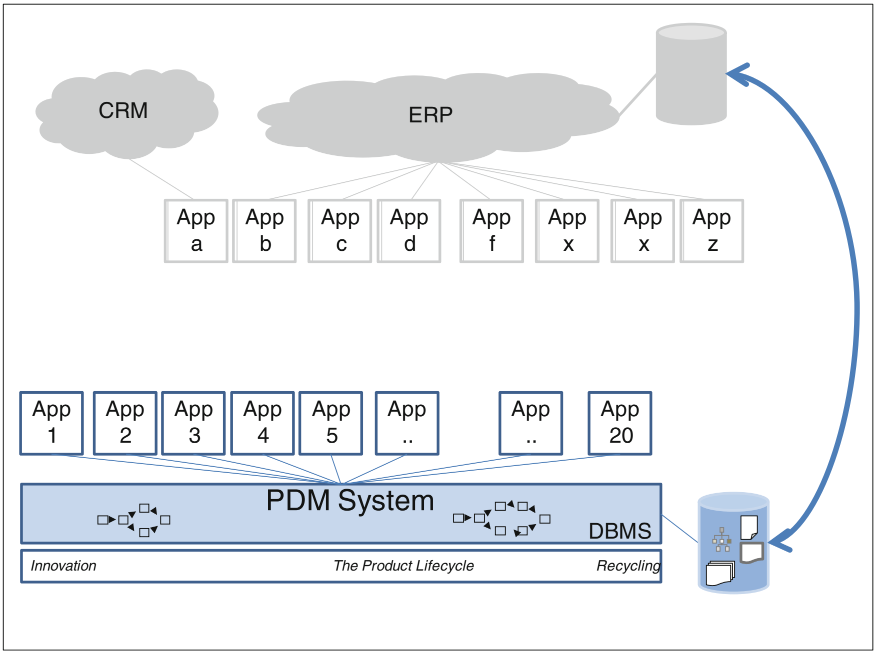

Fig. 5.11 The PDM system in the enterprise world

buying departmental applications, it looked for enterprise applications such as PDM systems (Fig. 5.11). When new applications were needed, IS didn't focus on departmental benefits, but thought enterprise-wide, and looked for most benefits for the company. Instead of continually adding new applications, it tried to reduce the number of applications. As IS budgets were cut, IS looked to harmonise across departments and sites. Duplicate applications were removed. Interfaces were removed. Data was put in databases, rather than in files. Duplicate functionality in different applications was minimised.

5.2.6.3 PLM Application Architecture

There's a wide range of activities across the product lifecycle. Many applications are needed to support them. These are positioned in a PLM Application Architecture. This becomes a common reference for everyone in the company working with PLM applications. It describes the IS components of the PLM environment, their positions and relationships, and shows how they support the business. It answers questions such as: What applications do we have? Where are they? What product data do we have? Where is it? How is it organised logically? How is it organised physically? Which platforms and systems do we have? Where are they? Which interfaces? Which communications systems? What function is in each application?

5.2.6.4 PLM Application Strategy

The PLM Application Strategy defines how IS capabilities will be organised to meet PLM objectives. It reflects the PLM strategy and the business objectives, and includes principles and practices addressing the PLM resources (Fig. 5.12).

5.2.6.5 PLM Application Management Processes

There are so many PLM applications, and it's so important to get them working right, that many companies have a special PLM Applications Group to select, maintain and improve them. The PLM environment is complex with frequent changes. And there's always pressure to reduce costs. As a result, the group's services have to be excellent, efficient, and cost-effective. To achieve these targets, most groups follow recommendations such as those in "ISO/IEC 20000-1:2011: Information technology—Service management—Part 1: Service management system requirements". These provide frameworks and best practices for identifying, planning, delivering and supporting PLM services.

5.2.7 *KPIs for PLM Applications*

A Key Performance Indicator (KPI), or metric, is a quantifiable attribute of an entity or activity that helps describe its performance. It can help manage and improve the entity or activity. KPIs for PLM applications (Fig. 5.13) help a company to quantify the performance of PLM applications.

value	platforms	support	budgeting constraints
user groups	customisation / configuration	maintenance	business priorities
skill set	packages	disaster recovery	business functions
training	data storage / archiving	outsourcing	hardware/software
schedule	security	new technologies	core competencies
plans	performance / availability	buy or make	vendor management
costs	human resources	networks	risk management

Fig. 5.12 Subjects addressed in the PLM application strategy

total cost of ownership (TCO)	perceived value ($)	average time to solve a problem
number of users	annual number of problems	annual number of new versions
annual running costs	achieved ROI	usage (hours)

Fig. 5.13 Potential KPIs for PLM applications

5.2.8 The Importance of the PDM System in PLM

At first sight, it may appear that the need for a PDM system results from the need to manage the large volumes of product data generated by PLM applications. However, it's actually the business reasons, the needs to improve productivity and to respond more flexibly to customers, which have become the driving force to achieve better management of product data. PDM oversees the creation and use of product data throughout a product's life. It's by improving the use, quality and flow of product data and by supporting new product development and support activities, that the PDM system helps reduce lead times and product costs, and improve competitivity, market share and revenues. PDM systems offer the potential for many improvements (Fig. 5.14).

PDM systems offer the potential for better use of resources, better access to information, better reuse of design information (since this will be under better control), better control of engineering changes, a reduction in development cost (since it will be easier to be aware of real costs during the engineering phase), a reduction in lead-times, and improved security of product information. PDM systems help companies to improve their competitive edge. They help improve the productivity of the product development and support activities. They allow companies to be more flexible in their manufacturing. They help companies improve the quality of their products, and they allow them to be more adaptable to market requirements, and more supportive to customers. They help improve the way that large numbers of people, co-located or distributed, can work together.

Reduced lead-times open up new market opportunities and possibilities to improve profits. They also reduce market risk by reducing the time between product specification and product delivery. The sooner that customers use a product, the sooner their feedback can be incorporated in a new, improved version. If quality is improved, not only will customers be pleased, but there will be a reduction in scrap, recall and rework. Corresponding administrative activities, and their costs, will be reduced.

A PDM system will help improve product development productivity. Product development managers will know the exact status of a new development. They'll be able to assign resources better, and release designs faster and with more confidence. Design engineers will know which parts are available and which procedures should be followed when designing new parts. Manufacturing engineers will be able to see how similar parts have been made previously.

better use of resources	better reuse of design information
reduction in lead times	better control of engineering changes
better access to information	improved security of product information
reduction in development cost	better support of customer use of the product

Fig. 5.14 Potential performance improvements with PDM systems

With a PDM application ....
it's much quicker to access and retrieve product data than it is to access paper documents
costs are reduced. Once the data is in the application it can be displayed on a screen. There's no need to pay someone to get the document. There's no need to make a physical copy
quality is much better. The information shown on the screen is the information in the computer
data is secure. It doesn't get torn, it won't be mislaid, it won't be the wrong version
the information is available almost immediately. There's no need to wait for a document until someone gets back from lunch, or recovers from being sick
time is saved. There's no need to wait while someone who recently joined the company asks his or her boss where a particular document can be found
many problems are avoided. There are no longer issues such as someone else having the document, or someone modifying the document but not telling anyone, or someone modifying the entity described in the document but not modifying the document

Fig. 5.15 Potential performance improvements with PDM systems

A PDM system can provide exactly the right information at exactly the right time. Having digital product data under PDM control helps attain the objectives of improved product development and support in several ways (Fig. 5.15).

5.3 Reality in a Typical Company

5.3.1 Generic Issues with PLM Applications

Although there are thousands of applications, and they are used for many different things in very different situations, there are some issues that are common to many applications (Fig. 5.16).

5.3.1.1 Ambiguous Name and Unclear Scope

The functionality of an application is often unclear from the name of the application. Many umbrella terms such as Computer Aided Design, Computer Aided Engineering and Computer Aided Manufacturing are used with a wide range of different meanings. Different vendors include different functionality within apparently similar applications.

It's often unclear, from the name, exactly what an application does. Some groups of applications, for example Computer Aided Manufacturing, Computer Aided Production Engineering and Digital Manufacturing applications, are similar, and have overlapping functionality.

Naming	Change, Version Management	Island of Automation
Definition, Scope, Functionality	PLM APPLICATION	Ownership, Training, Support
Architecture, Overlap, Duplication	Data Management, Exchange	Integration, Interfaces, Customisation

Fig. 5.16 Issues common to many PLM applications

5.3.1.2 Islands of Automation

There are thousands of applications in the PLM environment. Any one of these may, in some circumstance, be required to work independently of other applications. As a result, it needs all the functionality that makes it usable. This could include, for example, user interface, mathematics and data management functionality. To be able to work independently of other applications, it must be able to work as an "Island of Automation". In some circumstances, it's an advantage to be able to work independently of other applications. However, in other circumstances, it can lead to disadvantages. For example, it results in duplication of functionality. And it slows the flow of data. It may lead to error-prone manual transfer of data between applications.

One part of a company, such as a department, can overcome the problem of having many Islands of Automation, in part, by using only an "integrated set of applications" from a single vendor. In this case, some of the physical data transfer problems will be reduced, and the vendor may provide some means for improving the flow of information between the individual applications. In all but the smallest departments, however, it won't be feasible to buy only an "integrated set of applications" from a single vendor.

In the future, as current technologies evolve, and new technologies are introduced, it can be expected that new Islands of Automation will appear. They may be of great importance to individual companies, who will acquire them even if they aren't integrated. For the foreseeable future, companies will have to cope with incomplete integration, application-related files and the resulting problems of working with information that's connected in real life but unconnected in the applications they use. These problems, through redundant data, redundant data entry, redundant conversion of data, and redundant application functionality lead to increased operating costs.

5.3.1.3 Departmental Islands, Supplier Islands

Even if one part of a company, such as the design engineering function, could overcome all these problems and consolidate all its computing and communications activities into one Island of Automation, it would still face the problems of working with the Island of Automation in the Manufacturing function, and with the design engineering function in partner companies. It's unlikely that these companies would have chosen exactly the same Island of Automation solution. They could have chosen a different solution, or they might have decided to work in an environment that's not integrated.

5.3.1.4 Interface and Integration Need

Many PLM applications need to share and exchange product data (such as part numbers, version numbers, product costs) with other applications in the company (Fig. 5.17).

ERP applications (which manage all sorts of company assets, inventories, capacity, schedules, forecasts, orders, costs and revenues)
SCM applications (which manage all sorts of material and financial information across the supply chain)
Maintenance, Repair and Operations (MRO) applications which track the status of products, their configurations, repair processes, and upgrade status
CRM applications (which manage all sorts of customer information including customer requests, requirements, experience and problems)
Marketing and Sales applications (which help implement high-impact Marketing strategies and effectively empower sales associates to see sales trends and identify customer needs earlier)
NC controllers (which drive motors on machine tools to produce components and products)
Human Resource Management applications (which realise the potential of employees, with up-to-date information about performance, payroll, benefits, and career path)

Fig. 5.17 Applications that may need to be integrated with PLM

5.3.1.5 Overlapping Data Management Functionality

Since most PLM applications have to be able to work in a stand-alone mode, they need to be able to store the product data that they create and use. For example, they may need to store product names and engineering drawings. The application developer develops specific data management functionality to do this. However, the developers of all other PLM applications will also develop specific, but different, data management functionality for their applications. The result is overlapping, duplicate data management functionality.

5.3.1.6 Different User Interfaces

As well as storing data in their own specific ways, many PLM applications have their own specific user interfaces. And their approach to other common functions, such as maths functions, may also be specific to each application. Each time that someone uses one of these applications they waste time in first learning, and then remembering, the specifics of the application's interface and functionality.

5.3.1.7 Organisational Match

Application programs often reflect the organisational environment for which they were created. In the past, organisations have tended to be departmental, and application programs matched the functionality and data needs of a particular department. This limits their usefulness across the lifecycle.

5.3.1.8 Limited Operating Environment

To manage products across the lifecycle, most companies use computing resources of various types from different vendors. Some of these resources may be stand-alone, others linked together over various types of networks and connections. They may run on a variety of operating systems. Some of these will be proprietary, not standardised. Others will, in principle, conform to a standard. However, even those that are, in principle, standardised, may have minor differences, particularly between different versions and releases. Many PLM applications only run on one operating system, so aren't usable on all the company's computing devices.

5.3.1.9 Versions

The different versions of applications, such as CAD applications, are a potential source of problems. The capabilities of successive versions of a CAD application can be incompatible. The application vendor may upgrade the application with the intention of providing better functionality and richer information content. However, by doing so, it may create the situation where an earlier version can't make use of all data created under the new version, and the new version can be limited in its ability to use data created under the earlier version.

5.3.1.10 Legacy Applications

The computer hardware and operating system at the heart of an application, such as a CAD application, are also a potential source of problems. If past trends continue, hardware currently in use won't be in use in 20 years' time, yet some companies will need, in 20 years' time, to access data currently being created. It could be difficult for users to re-create exactly the present environment, unless the company intends to archive its computers, operating systems and PLM applications, as well as its product data.

5.3.2 Generic Issues with PDM Systems

There are many PDM systems on the market. The detailed data management activities of individual companies are different. As a result, implementations of PDM systems tend to be company-specific. Nevertheless, there are several issues common to most PDM systems (Fig. 5.18).

Naming, Functionality, Scope	Change, Version Management	Interfaces
Data Model, Workflow	PDM SYSTEM	Ownership, Funding, Support
Fit in IS Architecture	Customisation, Installation	Everyday Use

Fig. 5.18 Issues common to most PDM systems

5.3.2.1 Naming, Functionality, Scope

The functionality and scope of a PDM system are often unclear from the name of the system. The scope of PDM systems can be very different. Some may have a lot of functionality and have been designed to support product data across the lifecycle. Others may only have limited functionality, and be focused on data management for specific parts of the lifecycle.

5.3.2.2 Change, Version Management

One of the driving forces for PLM is the high level of change in the product environment. However, change can be an issue for PDM systems.

A new version of a PDM system can raise problems. The previous version may have met a company's requirements perfectly. The change in the new version, while being of great value to most companies, may raise problems for others.

Changes to other applications can also be an issue. If the data structures in an application interfaced to the PDM system change, then the interface may need to be changed. If many applications are interfaced to the PDM system, and each one changes a few times each year, the situation can get complicated.

5.3.2.3 Interfaces

PDM systems need to share and exchange product data (such as part numbers, version numbers, product costs) with other applications in the company. Some interfaces may be provided by the vendor as part of the PDM system. Others may be developed with the Application Programming Interface (API) provided with most PDM systems. The API enables the team supporting the PDM system to create, using the system's objects and routines, any additional functionality that's needed. For example, an interface may be needed between the PDM system and an application that's been developed in the company.

Another source of problems can be the interfaces between PDM and other applications. Unless all the interfaces exist, some users will work entirely outside the PDM system rather than sometimes inside and sometimes outside.

Many PDM systems have their own specific user interfaces. It can take a long time for users to learn the details.

5.3.2.4 Data Model, Workflow

The PDM system may have issues related to the flow, use and quality of product data. The system may not be able to handle all data types. It may not be able to store data where it's needed. There may be incompatibility between data structures.

Classification mechanisms may be inappropriate. There may be no way of encouraging re-use of information.

The system may only be set up to handle certain types or formats of documents, and not be able to handle others. It may only be able to handle a limited number of versions and/or variants of a particular document. It may only be able to apply the same release process to all documents of a particular type, even though the company has different ways of releasing them.

The PDM system may only be able to store all data in one physical location, yet use of data may be required at two or more locations. In some cases, it will be the cost of communicating information between different sites that's the problem, in other cases it may be security or confidentiality.

There may be problems with the structure of information. Different departments may structure the same information in different ways. Unless the system is capable of accepting different structures (or views) for the same information, there may be issues as people try to ensure their preferred structure is chosen as the standard.

Problems may arise if a company has several naming, numbering and classification conventions, but the system is limited to one convention.

5.3.2.5 Ownership, Funding, Support

A PDM system is cross-functional, enterprise-wide. It doesn't belong to any one of the functional departments. As a result, it may be unclear who is responsible for it. It may not be obvious how it will be financed. It may not be obvious which practices should be followed in addressing it, or which jargon should be used to describe it. It may not be clear which rules should be followed when managing information in a PDM system. There may be problems cost-justifying the PDM system. Which department or departments should pay the costs of a system that's used by several departments? How should costs be distributed so that the department that gets the most benefit pays the most? How can the running costs of the system be shared equitably? This is especially difficult to achieve if the system is installed in one department, supported by people from another department, and used by people from many other departments.

Insufficient investment is a common issue with PDM systems, as is the use of inappropriate project cost-justification calculations. These may generate over-optimistic expectations. The targets put in place to drive the implementation and use of a PDM system may be inappropriate or even unattainable.

5.3.2.6 Fit in IS Architecture

With a primary purpose of managing product data, a PDM system needs to be closely linked to the other PLM applications that create and use product data. The PDM system needs to fit seamlessly into the company's IS architecture.

5.3.2.7 Customisation, Installation

At installation time, all sorts of issues can arise with a PDM system. Its implementation may take much longer than expected. The people who selected the PDM system may pull out before the system is installed, leaving implementation in the hands of people who neither understand the objectives nor are motivated to succeed. Insufficient training may be given to users and the system support team. There may be no guidelines describing how the system should be used. There may be problems with the system itself. It may not work the way the vendor claimed it would, or it may have bugs, or it may not be documented, or there may be no procedures showing how it should be used.

Other implementation problems can be due to poor understanding and definition of the workflows. Problems can also arise at the level of individual activities if the system doesn't work the way the company wants to carry out specific activities such as release and change management. It's important that the workflow be understood and clearly defined. Otherwise it's going to be difficult to use the PDM system to support it. PDM can't be used effectively if key issues are unclear (Fig. 5.19).

5.3.2.8 Everyday Use

Some issues may arise when the system starts to be used on an everyday basis (Fig. 5.20). Problems may occur if new developments promised by the vendor don't appear. In-house system developments can also be a source of problems. Sometimes, developments won't be made because funding is cut or because they have low priority on the waiting list. Another problem that may arise after installation is that the project budget, in particular the training budget, is slashed. The funding of the PDM system support team, the group that should make sure the system works on an everyday basis and should provide everyday support to users, may be cut. As the PDM system gradually takes hold, some departments may feel they're losing control or power. As a result they may start to block its use and hinder further development.

unclear who has access rights at each step	unclear how information flows in the workflow
unclear steps of the workflow	unclear what the information in the workflow is being used for
unclear what happens at each step	unclear which conditions to be met before moving to the next step

Fig. 5.19 Examples of lack of clarity concerning the workflow

errors and inconsistencies in the system	lack of funding
lack of interfaces to other applications	missing functionality
failure to make the necessary organisational changes	lack of training and support

Fig. 5.20 Potential issues when everyday use starts

There may be issues related to top management such as lack of commitment, lack of leadership, lack of support and lack of patience. Problems at the middle management level may be due to conflicts with personal goals, empire-building, and fear of loss of power. Users may fear that the PDM system will play a Big Brother role, or may lead to job losses. Problems can also arise if members of the PDM project team don't work together effectively. Other issues may also affect everyday use of PDM (Fig. 5.21).

Users may run into problems. For example, the system may crash or malfunction frequently. Users may complain that it's not user-friendly and takes too long to learn to use. They may suffer from poor response time as the amount of product data in the system increases. System upgrades may be necessary and the result may be that system use becomes too expensive. In some areas, the system may not behave as expected, and time-wasting workarounds may be necessary. As users get to know the system, they may find that functionality has been oversold. Functions they need may not exist, or may only be partially implemented. The system may only handle a limited number of document types. Documentation and on-line help may not exist for some key functions. There may be no guidelines describing how the system should be used. Necessary customisation may turn out to be too difficult or too time-consuming.

The people involved in PDM system administration and support will hear all about the problems that users are having. They may also have their own problems (Fig. 5.22).

As time goes on, it may become clear that the wrong vendor was chosen. New versions may be delivered late, lack promised functionality, and have quality problems. Maintenance costs may become unacceptably high. There may be no upgrade path between successive versions. Key individuals may leave the vendor. Eventually the vendor may go out of business.

lack of agreement and co-operation between departments	departments using different definitions
difficulties in getting cross-functional activities to occur	departments using different standards
departmental barriers preventing information flow	issues with customers and suppliers

Fig. 5.21 Issues affecting everyday use

the system may be difficult to set up for more than a prototype
system administration may be inflexible, time-consuming and error-prone
previously hidden limitations may appear in the definition of roles and processes
previously hidden limitations may appear in the creation of reports
the system may not work on all the platforms where it's needed
the system may be difficult to integrate with other applications
the vendor may be unable to provide good, well-trained support staff

Fig. 5.22 Possible concerns of the PDM system support team

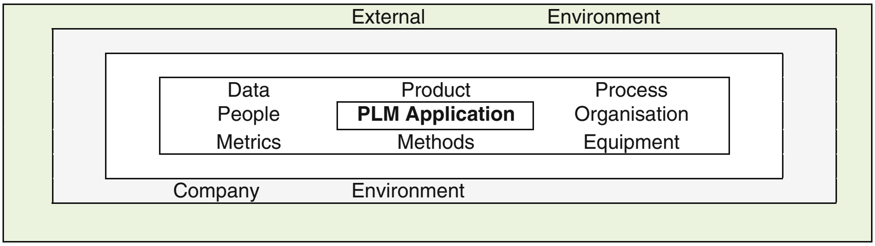

Fig. 5.23 No PLM application is an island

5.3.3 Interaction with Other Activities

No PLM application is an island (Fig. 5.23), isolated from the rest of the company. All PLM applications are closely related with other PLM components. They are also influenced by other forces within the company, and outside the company.

For example, if a new PLM application is implemented, documentation will have to be developed to show how it should be used and supported. People will have to be trained to use and support it. The application may lead to changes in some steps of a business process, so the process description will need to be changed. The new application may replace existing applications, so these will need to be retired. The product data in the existing applications may be archived, or may need to be migrated to the new application. The new application may enable new working methods. These will need to be documented. People will be trained to use them.

PDM systems are also closely related to the other PLM components. If a type of document that's managed by the PDM system is changed, then it may be necessary to change the way the PDM system manages the document. Relationships with other objects may need to be changed. If an application that's interfaced to the PDM system is modified, it may be necessary to modify the interface. The information about users in the PDM system will need to be updated when new people join the company, or when people change roles or positions in the company. When business processes are changed, workflows managed by the PDM system may need to be changed. If a new type of product is developed, a new product information structure may need to be created in the PDM system.

5.3.4 Interaction with Company Initiatives

Most organisations have many initiatives running. These initiatives have names such as Enterprise Content Management, Knowledge Management, Business Intelligence, Corporate Intranet, Corporate Cloud, Web 2.0, IS Outsourcing, etc. Many of these Initiatives address applications. Each initiative is focused on its own success and tends to see other initiatives as competitors. It's likely they'll see the

PLM Initiative as a competitor for resources and for successful outcome. It's important for the PLM Initiative team to identify the other initiatives, and find out which initiatives will be supportive of PLM and which won't. And then work out how to achieve mutual success with all of them.

5.3.5 Generic Challenges with PLM Applications

The PLM application-related challenges that a particular company faces could come from several sources (Fig. 5.24).

One of the challenges of PLM for a particular company is to identify the PLM applications that are most relevant to the activities on which the company wants to focus its efforts. The role, and the potential benefits and disadvantages, of each application should be clearly understood so that it's possible to see if, and how, it could best fit into the PLM environment.

A company could face several challenges related to PDM systems. They could come from several sources (Fig. 5.25).

5.3.6 A Generic Vision for PLM Applications

In a PLM Initiative, most companies will want to develop a PLM Vision, a view of their future PLM environment. Of course, implementation of PLM in different companies will be different. However, the Vision for the future is likely to be similar. A complete PLM Vision addresses all of the components of the PLM Grid. Sometimes though, a company will just work with a Vision of the components of most interest. Some typical contents of a PLM vision for PLM applications are shown below, grouped into six main sections.

poorly used applications	too many applications	wildcat applications
under-used applications	too much customisation	duplicate applications
high cost of applications	too many interfaces	slow response to new technology
insufficient user support	too many changes to applications	not integrated with the business

Fig. 5.24 Potential PLM application-related challenges for a company

slow response time	duplicate PDM functionality	too much customisation required
high costs for support	deficiencies in the PDM system	too much bureaucracy in system use
inappropriate data model	poorly designed implementation	multiple PDM systems in the company
insufficient user support	limited workflow functionality	too much product data managed outside PDM

Fig. 5.25 PDM system-related pressures

5.3.6.1 Digital Company

Activities in all of our business processes across the product lifecycle will be supported by PLM applications. All our information will be digital. We'll be a truly digital company.

5.3.6.2 PLM Application Architecture and Strategy

There'll be a document describing our PLM application architecture. There'll also be a document describing our PLM application strategy.

5.3.6.3 Product Data Management for PLM

A Product Data Management (PDM) system will provide people in the product lifecycle with exactly the right information at exactly the right time. Having digital product data under PDM control will help achieve the objectives of improved product development and support. With PDM, it will be much quicker and easier to access, retrieve and reuse product data. The PDM system will manage all data defining and related to the product across the product lifecycle from initial idea to retirement. It will provide controlled access to correct versions and configurations. It will enable tracking of product configurations.

5.3.6.4 PLM Applications Throughout the Product Lifecycle

PLM applications, such as Automated Product Idea Generation, Virtual Engineering, Digital Manufacturing, Collaborative Product Support, and Computer-Aided Recycling, will be used in the corresponding phases of the product lifecycle. Application programs will also be used to support management of the Product Portfolio.

The best applications will be used across the product lifecycle. Advantage will be taken of modern technology, such as 3D printers that produce prototypes directly from a CAD model. Manufacturing and maintenance equipment will be simulated and optimised before use. Simulation will help study the performance of a manufacturing plant before it's been physically built or implemented. Computer-based simulation is low-cost and effective. It uses the models designed in the computer that would normally be the basis for building the plant. It makes it easier to evaluate before implementing. It allows errors to be identified and corrected before they are implemented. Models can be built, tested and compared for different concepts. "What-if" analysis can be carried out. Recommendations for improvement can be made.

5.3.6.5 PLM Application Standardisation

We'll save a great deal of time and money across the product lifecycle by using standard business processes, standard product data and standard PLM applications. Without such standards, each process or application interface would be a source of problems. Without such standards, duplicate applications are a source of waste. PLM applications will be harmonised over all sites, and across the lifecycle. There'll need to be very good reasons to have, for example, different CAD applications, or different versions of the same CAD application, on different sites. Such differences can be a barrier to communication and progress.

5.3.6.6 Interfaces

PLM applications contain important product data that must be made available to other enterprise applications such as ERP, CRM and SCM. And PLM applications need to have access to information that's managed in other enterprise applications. As a result, some interfaces will be needed. We'll make sure they are lean and effective.

Interface programs are costly to develop and maintain, error-prone, and potential breakpoints impeding smooth process and information flow. As a result, all interfaces will be reviewed frequently and their existence questioned. The target is to eliminate 20 % of interface programs each year.

5.4 Application Activities in the PLM Initiative

A PLM Initiative takes a company from its current PLM situation to a desired future PLM situation (Fig. 3.32). More than 80 % of the PLM Initiatives in which we've been involved have included applications in their scope.

5.4.1 Application-Related Projects

In the typical PLM Initiative, there are usually many projects related to PLM applications (Fig. 5.26), Depending on the Initiative, some of these projects may run independently. Some may run in parallel with others, or overlap them. Others

define the PLM Application Architecture	manage projects related to PLM applications
define the PLM Application Strategy and Plan	carry out risk analysis of the application environment
provide training about PLM applications	harmonise applications across the company
develop a PLM application glossary	select and implement a PDM system
document the PLM application landscape	select and implement other PLM applications
review the status of PLM applications	define KPIs for PLM applications

Fig. 5.26 Examples of projects related to PLM applications

may be linked to Initiative projects related to business processes, product data and/or change management.

At the beginning of most PLM Initiatives, some people know a great deal about PLM applications. However, others lack some knowledge, and yet others know very little. As a result, it's useful to provide appropriate training and/or education. An introductory PLM application course can help people find out about some of the basics of PDM systems and other PLM applications. They can learn together some of the basics, jargon and vocabulary. Useful information about PLM applications can also be gathered from books, journals and web-sites, from conferences and seminars, from demonstrations by vendors of PLM applications, and from visits to other companies using PLM.

It will be helpful if PLM application training is given at the beginning of the Initiative from a neutral, experienced expert. Otherwise, it's only too likely that people will go round in circles for a considerable time, with everyone becoming more and more attached to the idea that PLM applications exist mainly to solve their own everyday problems. For example, some will see the PDM system as being only a solution to CAD data management problems. Some will see PLM applications just as a way of managing Bills of Materials. Some will see them as being the answer to configuration management and traceability problems. Some will see them as a way of making sure that their favourite procedures are implemented. As time goes by, everyone will become more and more convinced that they alone are right. The intervention of a neutral, experienced expert at an early stage can prevent this negative and resource-wasting state of affairs arising.

5.4.2 PLM Application Status Review

In many PLM Initiatives, a review of PLM applications is carried out. This has the benefit of making the content and status of the PLM application environment visible and understandable to everybody. It provides a clear description of the current state of PLM applications in the company. An analysis of the PLM application environment often shows room for improvement. There may be duplication of functionality between some applications, high spend on maintenance of others. Old versions of some applications may still be running. Different sites may use different versions of the same application to do the same task. Different sites may use applications from different vendors to do the same task. The review may lead to some general conclusions about PLM applications, findings about risks and issues, and suggestions for improvement. The general conclusions about PLM applications are often high-level and oriented to strategy (Fig. 5.27).

The PLM Application Status Review can highlight the main sources of risk for PLM applications (Fig. 5.28). These can come from several areas. Making them visible is a first step to finding ways to reduce the risks.

The review can also show issues resulting from these risks (Fig. 5.29). Once these are clear, ways can be found to prevent them occurring again in the future.

PLM application strategy out of alignment with business strategy
PLM application strategy out of alignment with business requirements
PLM application strategy out of alignment with business processes
PLM Application Team unable to respond to changing business needs
poor success rate of PLM application project completion
poor utilisation of PLM application resources
very low profile of PLM applications on the business horizon
PLM misunderstood by the CIO Department
PLM applications misunderstood by top and middle management

Fig. 5.27 General conclusions about the company's PLM applications

project management	change management
requirements management	project team issues
user issues	new version synchronisation
scope control	lack of training

Fig. 5.28 Frequent sources of risk for PLM applications

errors in the implementation project schedule	too much customisation of PLM applications requested
departure of key team members	breakdown of project management methodology
scope creep	lack of management commitment
requirements explosion as new subjects appear	lack of user commitment and involvement
continually-changing requirements for PLM applications	unrealistic PLM application implementation plans

Fig. 5.29 Issues arising from risks related to PLM applications

improve PLM application performance	reduce maintenance spend
remove applications no longer in use	harmonise applications across sites
remove duplicate applications	apply standard procedures
remove overlap of functionality	improve interfaces

Fig. 5.30 Improvement actions resulting from PLM application analysis

The PLM Application Status Review can also identify improvement actions (Fig. 5.30). These can address PLM applications, the way that they are organised, and the people who use and support them. The review provides a good basis for identifying next steps, and supports the development of strategies and plans.

Another output from the PLM Application Status Review can be a set of criteria to be used in selecting PLM applications (Fig. 5.31). This can be based on the company's experience of selecting PLM applications.

ease of use	industry presence
fit to business strategy	level of support from vendor/partner
fit to IT architecture	reliability of the software
functionality	ROI and TCO
growth potential	vendor's track record

Fig. 5.31 Application selection criteria

executive sponsorship	documented user procedures	system testing
win-win contracts with partners	data migration strategy	focused project
user/SME participation	scope management	project plan
process owner involvement	minimise customisation	OCM strategy

Fig. 5.32 Success factors for implementing PLM applications

Similarly, on the basis of experience implementing PLM applications, success factors for application implementation can be identified (Fig. 5.32).

5.4.3 Software Development Approaches

There are two main approaches to software development and implementation. The classical IS approach to system development has been the Waterfall approach. This is a sequential development approach in which progress is seen as flowing steadily downwards (like a waterfall) through various phases such as Conception, Initiation, Analysis, Design, Construction, Testing, Production/Implementation and Maintenance. The Waterfall approach has been applied with different numbers of phases and different phase names (Fig. 5.33).

The Waterfall approach cuts a large project up into a set of smaller sequential phases. That makes it easier to plan, manage and execute provided that no changes occur. However, changes nearly always occur, breaking the sequence and leading to confusion. Sometimes a phase has to be restarted. Sometimes, it's necessary to restart a previous phase. Sometimes, rework tasks are added to the Maintenance phase. As a result, the Maintenance phase includes much more than maintenance. It becomes a major activity as the system is modified to meet user requirements. The end result of all the changes is that a project that takes a Waterfall approach often takes a long time, but fails to produce the solution required by the users.

The Agile system development approach is an iterative approach which accepts that user requirements can't be clearly defined initially, and in any case will change as the users get to know the new system. In the first step, a high-level project plan and a high-level view of the targeted system are defined by the project team working

		Naming 1	*Naming 2*	*Naming 3*	*Naming 4*
Phase					
1		conception	feasibility study	requirements	requirements
2		initiation	requirements analysis	design	design
3		analysis	system design	implementation	coding
4		design	detailed design	verification	integration
5		construction	programming	maintenance	testing
6		testing	testing		installation
7		implementation	use		maintenance
8		maintenance			

Fig. 5.33 Different phases and names in different waterfalls

closely with user representatives. Then, working from the high-level plan, the next steps are defined by the project team. The team then works on these steps, again in close collaboration with users, to detail them and carry out the activities. A more detailed view of the system is created. This is reviewed and validated (or not) by the users. The next steps are agreed and then executed. At each step, a prototype is built to meet the user's apparent requirements. Experience of its use provides input for the next step. Each step builds on the results of previous steps. Compared to the Waterfall approach, the Agile approach involves users throughout the project, and repeatedly tests the most up-to-date proposal for the system. This offers the possibility to identify any need for change and to make corresponding adjustments as early as possible.

Regardless of the approach chosen, Waterfall or Agile, careful consideration must be given to the overall project objectives, timeline, and cost, as well as to the roles and responsibilities of all participants and stakeholders. The approaches must use the same basic tactics. The location and origin of data, and its transformation through activities, must be understood. The flow of data and its uses and users at different times must be known. The control issues, such as access rights, audit trails and review points must be identified.

Most PLM Initiatives use a mix of Waterfall and Agile approaches. Many PLM application vendors and service providers have developed their own system development methodologies. These may use different terminology and have different numbers of phases and steps (Fig. 5.34).

5.4.4 PDM System Selection and Implementation

At a PDM Conference, a PDM project leader from a well-known company told me, with a sigh of relief, "At last we've finished our PDM project". "Congratulations", I replied, "How much money has PDM made for your company?" The project leader looked blank, and replied "Well, nothing so far". So I asked how many people were using the PDM system. The reply was "None so far." It was my turn to look puzzled. Isn't the purpose of a PDM project to get people to use a PDM system and make money? Fortunately the project leader then explained that they had succeeded

		Methodology 1	*Methodology 2*	*Methodology 3*
Phases				
1		Clarify user requirements	Discovery and Planning	Create and send RFP to vendors
2		Define the solution	Design	Evaluate replies to RFP
3		Select the vendor	Development	Select the system
4		Plan the project	Unit Testing	Finalise Business Requirements
5		Build	Testing	Define Functional Specifications
6		Test	Deployment	Develop Design Specifications
7		Deploy	On-going Support	System Development
8				System Implementation
9				System Support

Fig. 5.34 Different phases in different methodologies

in selecting a PDM system. The selection process had been difficult. It had taken more than a year, with many systems being considered, and everyone was glad that it was now finished.

It's strange how people often behave as if the purpose of a PDM project is to select a PDM system. Perhaps this is because it's a very clear milestone in the implementation of PDM. Perhaps it's because the selection of a new system seems much more exciting than everyday use of the system. Perhaps it's because the people who are involved in selecting a PDM system are rarely going to be users of the system, so selection of the system equates to the end of their involvement. These people often come from a central IS or technology group, or some other organisation that claims to be good at evaluating and introducing new technologies but doesn't actually use them.

Yet the real benefits of a PDM system come from its use. They don't come from its selection. Companies should focus much less on the selection process and much more on actually getting the system working and producing measurable financial benefits. People who think that selecting a PDM system is the objective of a PDM project have got it wrong. The objective of a PDM project is to increase company revenues or reduce company costs. Until a PDM project can demonstrate that it has done this, it's a failure, and it's certainly not finished.

5.4.4.1 Standard IS System Selection Approach

We often get asked to help companies who have taken the approach to PDM system selection shown in Fig. 5.35. This seems to be based on a standard approach to application selection proposed by their IS organisations.

5.4.4.2 Pitfalls of the Standard Approach

The standard IS system selection approach appears straightforward and simple, but it fails to address some important areas (Fig. 5.36). As a result, the system that is selected may fail to satisfy.

The standard IS system selection approach also glosses over some important factors that may hinder system success (Fig. 5.37).

Fig. 5.35 Standard IS approach to PDM system selection

1	identify PDM systems on the market
2	review functions and features
3	find out which PDM systems are used in their industry
4	make a short-list of systems to review
5	participate in vendor demos
6	select preferred system
7	negotiate price reduction
8	ask system vendor to suggest an implementation partner
9	start implementing

availability of PDM system support resources	fit of system to company procedures
scalability of system	project planning
suitable implementation partner	management and user involvement
total cost of ownership	Organisational Change Management
fit to the company's business needs	different needs for different industry positions

Fig. 5.36 Some areas forgotten in the standard system selection approach

a lack of basic knowledge about PDM systems	resistance to change
a lack of understanding of the potential benefits of PDM	interdepartmental disputes
other projects not liking competition from a PDM project	takes no account of company culture
difficulties in cost-justification	takes no account of company's PLM needs

Fig. 5.37 Factors hindering PDM system success

customisation can make a system exactly fits the business needs
customisation can make a system easier to use
customisation can provide better control of data access and data entry

Fig. 5.38 Some advantages of customisation of PDM systems

high development cost	risk of creating errors elsewhere in the PDM system
high maintenance cost	re-assessment needed at each new system release
slower implementation and update	risk that customisation is not compatible with the next release
risk of reduced PDM system performance	extra training, beyond standard system training, needed for users

Fig. 5.39 Some disadvantages of customisation of PDM systems

Another issue with the standard approach is that it doesn't openly address customisation and configuration of PDM systems. Although there are advantages to customisation (Fig. 5.38), most companies have found that they are outweighed by the disadvantages (Fig. 5.39).

Rather than customising, most companies prefer to configure the PDM system using the vendor's wizard. After they've done this once, they'll know how to do it the next time. And there should be no danger of their changes resulting in problems with system use.

5.5 Best Practice PDM System Selection

The following sections describe a best practice for PDM system selection. Although it's a "best practice", it could be totally inappropriate to some companies in particular circumstances. Its appropriateness depends a lot on the specific situation in which the company starts such a project.

In this case, the situation is as follows. The CEO has just told Ms X to select and implement a PDM system to manage product data. The company makes machines that have mechanical, electrical, electronic and software components. The company's business processes are perfect as the company has just finished a project to improve them. Ms X has been told not to stray into changing processes. In the business process improvement project, documents and other product data were improved. Ms X has also been told not to stray into changing product data. Her role is just to implement a PDM system to manage clearly-defined product data that is used in clearly-defined business processes. She's been told the system should include automated workflows for release management, change management and version management. Ms X is the company's most experienced and successful project manager. In addition to long practical experience in the company she's been certified by independent project management organisations.

There are many things to do in a PDM system selection project. Before starting work, it's best to identify and list the steps (Fig. 5.40). They don't necessarily have to be done one-by-one. It may be possible to overlap some of them. However, it's important to understand what's happening in each step.

5.5.1 Prepare the PDM System Project

The objective of this project step is to get the project started successfully. There are many small tasks in this step of Project Kick-Off (Fig. 5.41).

In view of the likely difficulty of the PDM project, and the many obstacles to its success, it's important to get the project off to a good start. The first requisite is top

1	prepare the PDM system project	12	write the Statements of Work
2	hold a kick-off meeting	13	prepare and sign the contracts
3	know thyself	14	high-level alignment and planning with partners
4	document the current situation	15	detailed design and planning
5	report business objectives and user requirements	16	build and planning for your PDM system
6	write the RFPs	17	test and validation
7	know potential partners	18	deployment
8	partner selection	19	go-live
9	make the PDM business case and project plan	20	support and sustain
10	report the PDM business case and project plan	21	PDM system performance review
11	pre-alignment with partners	22	evolve and extend

Fig. 5.40 Steps in PDM system selection and implementation

clarify the scope, objectives and targets of the project	list the phases and tasks of the project
clarify the governance mechanisms for the project	create a cross-functional project team
propose the way forward	make a high-level plan for the project
propose a project team and plan	make a high-level schedule for the project
document the proposal and plan	write the proposal document
get agreement to proceed	present the proposal document to management
clarify the endpoint of the project	get top management agreement and support
clarify the authority of the team leader	provide training

Fig. 5.41 Some tasks in project preparation

management support. Without top management support, the PDM project will fail. A PDM system is cross-functional, it's costly, and it's long-term. Top management should define the objective of the project, and give authority to the PDM project leader.

Top management should appoint a Steering Committee for the project. Steering Committee members should be executive stakeholders from those parts of the organisation involved in the management and use of product data. The Steering Committee should be held responsible for the success of the project. Top management should appoint a Project Sponsor from the Steering Committee. A cross-functional project team should be created. Its members should also be drawn from those parts of the organisation involved in the management and use of product data (Fig. 5.42).

Subject Matter Experts from across the product lifecycle will provide details about activities and product data. A solution architect from IS can help define requirements and the PDM architecture. A business process analyst can help with modelling the current situation. A support team member from IS can help understand current applications.

5.5.1.1 Hold a Kick-Off Meeting

It's important to inform all those who will be involved in the project about its scope, objectives and expected activities. If people aren't informed, it's likely that they won't contribute as well as possible.

5.5.1.2 Know Thyself

"Know Thyself" is one of the Delphic maxims. At the beginning of a PDM system selection and implementation project, two areas of self-knowledge are particularly important. It's important to know the reasons for the project. The reasons for the project are the business objectives. And it's important to understand the starting position for the project. The starting position for the project is the current situation within the company's PLM environment. Without knowing the business objectives and the current situation, it's impossible to know what the PDM system should do (the system requirements).

Planning	Marketing	Costing
Design / Engineering	R&D	Service
Manufacturing Engineering	Quality / Regulatory	IS
Sourcing / Production	Document Control	Logistics

Fig. 5.42 Typical functions providing steering committee and project team members

5.5.2 Document the Business Objectives

The business objectives for the PDM project are given by top management. Sometimes, they'll be available because the company has already defined its PLM strategy. In other cases, top management may not be able to provide them immediately. The project team will then have to piece them together from information that is more readily available, such as the company strategy, and individual Marketing, IS, R&D/Engineering and Manufacturing strategies.

The relationships between business objectives and PDM may also become apparent from the issues raised, and the concerns expressed, by top management when discussing PDM and related subjects. The project team should try to identify and confirm the four or five factors that are the most important for management.

What should the PDM system achieve for the company? There could be a need to reduce lead times significantly, or to improve product quality. There could be specific problems that have to be addressed, or relationships with powerful customers that need to be improved. There may be the intention to suppress some product lines, or to develop new, or improved, products. There could be plans to change the way clients and markets are addressed, or the way that work is carried out with design partners. Management may want to focus use of PDM on reducing product cost or may be aiming to reduce time to market by 30 %. The only way to find out about the business objectives of the PDM project is to discuss them with top management.

How will project success be measured? How much time and effort will management invest in the project? How and where will the PDM system be managed and used? Again, the only way to find the answers to these questions is to discuss them with top management.

If possible, the information obtained from management should be quantified. If the information is quantified, it will have more meaning, and can be used later both as a target and as a measure of progress. Key Performance Indicators should be identified for the business objectives. It's not enough to know that profitability and market share must be increased, some quantification is needed (Fig. 5.43). There are hundreds of ways that qualitative objectives like these can be met. Without quantified targets, it's not possible to differentiate between them. Once management has set the targets, the project team will be able to differentiate between possible solutions. If the project team believes that a PDM system can't help achieve a quantified target, it has to be able to tell top management why this goal is unrealistic. In such a case, the project team might be able to propose another solution.

Objective	*Target*
maximise product value to increase revenues and profit	increase revenues by 5%, reduce costs by 2%
improve innovation	bring 2 innovative products to market each year
increase product modularity and re-use	50% increase in number of modules and in re-use

Fig. 5.43 Business objectives and targets

The business objectives provide a clear business focus for the project team. This will help them greatly. In particular, it should prevent them from drowning in the sea of information that they'll produce. Without the business objectives, the project team can, all too easily, produce technical findings that are of no benefit to the business. With the business objectives, the project team has clear targets in sight, and can focus its activities and prioritise its recommendations.

5.5.3 Document the Current Situation

The project team can collect a lot of information about the current situation. To avoid wasting time, the team should first address four issues. Firstly, it needs to decide how it will collect information. And how it will report its findings. It needs to report in a way that will allow the PDM system requirements to be directly linked with the current situation. Then, it needs to understand which areas of the current environment to address. And it needs to find a way for its findings to be communicated to, and understood by, many people in the company.

The project team can hold workshops with managers and users to understand and clarify the current situation. Interviews are another way to find out about the environment. Questionnaires can be used to collect information. The PLM Grid (Fig. 1.5) is a useful tool for understanding which areas to address.

Maps and models are a good way of communicating the current situation throughout the company. They can be understood by top management, stakeholders from functional organisations, and other participants in the product lifecycle. However, modelling can become very expensive and time-consuming if pursued to a very detailed level. Initially the project team should only create high-level models. Further refinement can take place once it's possible to see where detailing is needed. A good example of a model is the swimlane (Fig. 3.13). This can be used to communicate a lot of information about roles, activities, product data, PLM applications and PDM systems. In many companies, models of this type already exist, and they can be expanded to include any missing details.

The models initially produced by the team should be easily understood by most users. The level of detail in the model of an activity can then be progressively increased until the team feels that all activity and information use is shown on the diagram. Other users can be asked to comment on the model. Models produced by users in neighbouring activities can be put together to show how the activities fit together and how information is transferred.

The users should be encouraged to explain their views of the overall product development and support process. The project team will learn how users receive work. The team will find out how users know when to start working on a project or to change to another project. The team will find out about the organisational hierarchy, the release procedure, and so on. They will see where information is created, how it flows, the way it's used, distributed and stored, and the corresponding management actions.

A complementary approach is to use the entity-relationship model. Again, individual users can be helped to produce their picture of the information they use. Once the entities have been identified, the next step is to identify their attributes. This approach, like all modelling activities, can be very time-consuming if carried out to the finest level of detail. The project team should decide how much time can be spent on modelling, and then define the most important activities to be modelled, and the amount of detail that is required. During the early stages, the project team may not need very detailed information. The models developed at this stage can be kept, and then worked on in more detail later, if required.

5.5.3.1 Activities in Scope

The project team should describe each activity in the scope of the project. Its objective and its position in the product lifecycle should be documented. If necessary, the activity should be broken down into its constituent tasks. The project team should identify who is involved in the activity, what they do, how long it takes, and how often it's carried out. There are many questions to answer about the description of the current situation (Fig. 5.44).

The information input, created, used, and output should be described, as should the sources of information and the definitions of information. If possible, the cost of the activity should be identified. Any applications used in the activity should be identified, their information requirements described, and their interfaces with other applications described. Management procedures and performance measures associated with the activity should be described. As well as understanding the overall flow and use of product data, the project team should also address the individual activities that create or use this information. These activities, such as engineering design, process planning and NC programming will probably be partly automated but still have a significant manual content. The project team needs to understand the information needs (input, processing, output and storage) of each activity area.

Review, release and change processes need to be understood. The project team should discover how many engineering changes are made, and the way they are made and recorded. The time and effort required to carry through changes should be

what is the scope of the product data that the PDM system should manage?
who are the creators and users of that product data?
which activities create and use this product data?
which PLM applications currently create and use this product data?
which systems currently manage this product data?
what equipment is currently used for PLM applications?
what equipment is currently used for systems that manage product data?
how is product data currently organised and managed?
how is product data currently released? How is it changed?
how is product data currently communicated?

Fig. 5.44 Examples of questions for the description of the current situation

brought to light. The roles and rights of users and managers at change and release time must be understood.

5.5.3.2 Product Data

As the individual activities are examined, the project team will begin to understand not only the information needs of each activity, but also some of the key parameters of the current situation (Fig. 5.45).

The different structures of product data such as Bills of Materials, assemblies and parts lists should be identified, and other associations such as product/drawing relationships clarified. The project team will begin to understand the way that packets, and structures, of information are created, modified, and moved between activities.

5.5.3.3 Users of Product Data

The project team will eventually be able to draw up a picture of the current organisation of the company from the point of view of product data. This will show the number of users and their locations, both geographically and functionally, and the way they store and communicate information. It will show where data is stored and how it's shared.

The users of product data should be identified. An attempt should be made to understand how users create, access, modify, store and communicate information. The access needs and rights of users and groups of users need to be understood by the project team. Shared and redundant data needs to be identified. Data standards and data ownership have to be understood.

It's useful to understand the activities of the various groups, or classes, of users. It will be found that different classes of user have very different activity profiles. Some users are mainly involved in creating product or process definition data, some in using data, others in managing documents, in managing changes, in managing configurations, in managing the overall product-related processes, or in managing relationships with other functions. Within each class it will be found that users often spend relatively little time in their main role. For example, individual design engineers may only spend about 40 % of their time defining product data. Another 40 % of the time may be spent on documentation, and 20 % on communication of various sorts.

number of existing products and parts	average time taken to process engineering changes
annual number of new products and parts	annual number of product development and support projects
annual number of engineering changes	annual number of models, drawings and other documents
average time to market	number of levels and constituents of Bills of Materials
current total volume of product data	volume of data created each year by PLM applications

Fig. 5.45 Quantifying the volume of product data

5.5.3.4 PLM Applications

An inventory of existing PLM applications should be made. It should include all applications related to products across the product lifecycle. As well as applications such as ERP, CAD, CAM and CASE, it should include applications used in analysis, project management, technical publications, documentation management and configuration management. The applications should be listed and described. What do these applications do? Who uses them? What functionality do they have? They may include a wide range of functionality including information management, change management, process management and product structure management. Their use of product data needs to be understood. Any data management systems in use should be closely examined. An inventory can be made of interfaces between applications. Interfaces and information transfer between systems should be described, as should transfer of information to and from supplier and customer systems.

The number and roles of the users of each application can be documented. Any KPIs related to PLM applications should be noted (Fig. 5.46). Any differences between applications in similar situations in different parts of the environment should be described. They can include the use of different versions of the same application, and the use of applications from different vendors to address the same purpose.

The project team should quantify the Information Systems ability and resources of the company. The aim of this activity is to avoid proposing a solution that requires IS support that the company's IS function is incapable of supplying or managing. The company's IS function may be centralised, or there may be a central IS group reporting to the CFO with local IS support teams in each individual function. In many cases it will be found that the IS group sees F&A as its primary client, and all other departments as secondary clients, yet is unable even to provide F&A with the right service. Similarly, IS support teams in individual functions are often unable to address strategic issues as they are overwhelmed with mundane tasks.

5.5.3.5 Product Data Management Systems

Information repositories need to be identified. An inventory should be made of existing ways of managing product data. These can include PDM systems, manual systems for the management of product data, and other product data management approaches (such as databases, file management systems and other applications). The types of data managed in each repository can be documented. Any other data repositories can also be documented. They may contain product data such as product names, Bills of Materials, manufacturing instructions, technical drawings, product specifications, CAD files, process specifications, quality data and test results. In

number of different PLM applications	annual running cost as % of budget	average age of applications
number of vendors providing applications	number of users of applications	number of interfaces
investment in PLM applications as % of budget	number of users of each application	cost of interfaces

Fig. 5.46 Examples of KPIs related to PLM applications

different industries, these may contain lists of ingredients, engineering drawings, CAD and other electronic data, and alphanumeric engineering documents. The current methods of creating, numbering, classifying, communicating, storing, archiving, obsoleting and otherwise managing product data can be understood, quantified and described. The cost structure for preparation and distribution of documents should be understood. The volumes of drawings and other documents in storage and under modification are important parameters. The cost structure for management of product data can be documented. The quantity of information communicated will be an important parameter for system and network design. The number and roles of people managing product data can be described. There may well be comparatively little-known users and repositories of product data that would be ignored without a wide-ranging analysis. Any KPIs related to PDM should be noted (Fig. 5.47).

Particular attention should be paid to product data in areas outside the traditional Engineering Department. There will probably be product data in production planning systems (such as ERP), NC part programming systems, process planning systems, analysis programs, test systems, quality control systems, office automation systems and spread-sheets. Suppliers, partners and customers may also manage, store and use the company's product data.

The management of product data, in particular at departmental boundaries, needs to be understood, as do data security and data integrity issues. The transition rules between the different states of information must be described. The rules vary along the product lifecycle, from the initial product concept, during which the information's owner can modify it at will, to the time when the product is in the customer's hands, and information can only be modified if strict conditions are met.

5.5.4 Identify PDM System Requirements

Having understood the current situation, and knowing the business objectives, the project team can now move on to the next step of the project. This is to define the requirements for the PDM system. A detailed PDM requirements document will be needed as a basis for the development, or more likely, for the acquisition of a PDM system. This document usually has several sections (Fig. 5.48).

5.5.4.1 The Requirements Document

This document can be used as the basis of the Request For Proposal (RFP) that will be sent to several potential partners in the next step. The document needs to be sufficiently detailed to enable the potential partners to make complete proposals. It

the cost of managing product data	the volume of product data managed electronically
the quality level of product data management	the volume of product data managed manually

Fig. 5.47 Examples of KPIs related to PDM systems

Section	*Typical Contents*
header	purpose of this document, date, authors, version number
introduction to the PDM system project	background about the company, objective and timeline of the project, its scope, the number of users and their locations, business processes
information management	check-in, check-out, numbering systems (part, document, project,etc.), classification systems, history management, audit trails, search, templates,objects, document types, metadata
infrastructure management	hardware, operating system, network, database, input/digitising, output/plot/print, archiving
interface management	program interfaces, data interfaces, reports/report interfaces, user interface, application programming interface (API)
information structure management	Bill of Materials, where-used lists, document structure, variants, project-related structures
lifecycle / workflowmanagement	lifecycle states, workflows
project management	stages, gates, deliverables, reports
portfolio management	project selection, pipeline management, resource allocation, project comparison, reports, statistics
system administration	user definition, user roles, user rights, configuration definition, set-up routines, backup, recovery
performance requirements	reliability, response time, availability
implementation	project plan, development and production environments, implementation phasing, dry runs
training	training for the system administration team, training for the users of the system, training for managers
legacy systems/data migration	applications to be migrated, data to be migrated
customisation/configuration	customisation strategy
security	security needs

Fig. 5.48 Typical sections and content of the requirements document

will be easiest for the project team to compare these proposals if they are complete and consistent. It wouldn't be easy to compare responses if the proposals are full of blanks and questions.

The document may be 20 pages long, 100 pages long or even longer. Some people will feel that it's bureaucratic or wasteful to write such a detailed document. However, its preparation helps to identify and clarify requirements, provoke discussion, and get understanding and agreement. The document can also show issues that have been discussed but are not included in the final list of requirements.

Each section may contain many individual requirements (Fig. 5.49). These should be in the form of understandable phrases. They will need to be understood by many people in the company. And by many people in partner companies.

access is required for the people and roles shown on the attached lists
the system must be able to show different states of a product structure (e.g., green for released, red for retired)
a variant should be identified by the part number with variant number and version number
the user must be able to create a hierarchy of projects
the system should include automated workflows for change management
the system should include automated workflows for release management and version management
a template must open automatically in Office when a user wants to create a document from that template
the system must be able to apply an electronic signature
the Export function must be able to export to MS Office for analysis and communication purposes
there must be a graphical means of monitoring currently running workflows
the system should accommodate the use of document templates
the visualisation function must have the ability to create and save exploded views

Fig. 5.49 Examples of requirements

all requirements maintained in one table	no overlap or contradiction between requirements
each requirement numbered and dated, with an owner	requirements will be under change control
clear and unambiguous descriptions of requirements	requirements understood and agreed by all stakeholders

Fig. 5.50 Examples of rules for the list of user requirements

5.5.4.2 Rules for Requirements

The project team should define the process of collecting, analysing, prioritising and managing requirements (Fig. 5.50). Otherwise, the situation can easily get out of hand.

The requirements document should show if a requirement is an essential part of the solution. If it is not, it should be assigned a relative importance factor. The first list that the project team produces will probably have very many entries. These will have to be examined closely, grouped and checked to ensure that duplicate or conflicting entries are not included.

5.5.4.3 Requirements Relative to the Current Situation

Among the key factors in determining the functionality that a company needs from a PDM system will be the quality, quantity, and coverage of the data management applications that are already in place. What do these applications do? What functionality do they have? How will they fit with PDM? Is the PDM system seen as a replacement for these applications? Is it an add-on? To what extent should it be integrated with them?

PDM systems can offer a wide range of functionality including information management, workflow management and product structure management. Some, or all, of these functions may already be present in a company's existing applications. Product structure may be managed in parts master, BOM and ERP applications. Some information management functionality may be built into another application such as a CAD application. Or it may be in an application developed in-house.

The required functionality will also depend on the way the company is currently organised, and the way it will be organised in the future. If everybody is on one site, then multi-site functionality may not be needed. On the other hand, if users are spread over several locations, multi-site functionality will probably be needed. If product development and support is carried out in teams, or the company has taken a Concurrent Engineering approach, then corresponding functionality would be looked for in the PDM system.

5.5.4.4 Gathering and Confirming the Requirements

The project team should be aware of many of the requirements for the system. However they should discuss their suggestions and gather further requirements through workshops with managers and users. And before reporting to top management, the team should confirm the list of requirements in a final workshop.

5.5.4.5 Report the Business Objectives and Requirements

The project team will collect a mass of data about business objectives and requirements. However, it mustn't present all of this to top management. Instead, it must distil it into an easily understandable document. Management should be able to quickly review the document. It should recognise the description of the current situation. It can confirm that the requirements correspond to the business objectives. The project team can try to produce a one-page overview that contains all of the most important data. This should show how the business objectives are to be met. Some information can be put in an Appendix. It could include the major functions and systems currently involved, with an indication of the volume and type of information created, used and communicated. The results should provide a complete picture of the use and management of product data in the company.

Once the project team has produced a brief executive summary of the main points, the team leader should present the results to top management, who will probably ask that they also be made available to functional managers. Some managers will probably want to look at the detailed findings, and it may take several weeks to get the results formally agreed, and the next phase of the project started.

Invariably, the investigation will have shown the opportunities for improving the management of product data, both by cleaning up the current process and by implementing a PDM system. The objective of understanding the way that product data is used and managed will have been achieved. The goals of "Know Thyself" will have been met. The reasons for the project will be clear. The starting position within the company's PLM environment will be clear.

5.5.5 *Know Your Partners*

The previous steps were about "Know Thyself". The objective of this step is to get to know potential partners and to select the partners for the rest of the project.

5.5.5.1 Identify Potential Partners

The first step is to identify potential partners. Their names can be included in a table so that everybody is aware of the scope being addressed (Fig. 5.51). In addition to selecting a PDM system vendor, the company may also want to select a system integrator to implement the system. The company may also be looking for a consultant to help with management of the PDM system project. It may also need a consultant to help with Organisational Change Management.

PDM System Vendor	*System Integrator*	*OCM Consultant*	*PM Consultant*
A	1	J	U
B	2	K	V
C	3	2	X
D	4	3	Y
E	5	5	2
F	C	B	4
G	E	C	C

Fig. 5.51 Potential partners

5.5.5.2 Write and Send the RFPs, Receive Replies

The project team can now write a Request for Proposal (RFP). This will inform potential partners that the company is looking for a PDM system and associated services. It asks them to make a proposal, usually before a certain date. The proposal should specify how the partner could respond to the company's requirements. It should also specify the proposed price and delivery conditions. The RFP isn't necessarily limited to the list of requirements. It can also include more information about the company. And it can ask for additional information about the potential partner, for example its financial situation, its employees and its customers. And it can ask for details about the products and services that are proposed.

5.5.5.3 Make a Short-List of Candidate Partners

After the replies to the RFP have been received, the project team needs to compare the replies about each candidate partner with the company's requirements. It will probably be apparent that some potential partners aren't suitable. They can be removed from the table, leaving a short-list of candidate partners (Fig. 5.52).

5.5.5.4 Benchmark Candidate Partners

Although the company may be looking for several partners, the most important choice usually concerns the PDM system. The other partners can be selected once the system has been chosen.

PDM System Vendor	*System Integrator*	*OCM Consultant*	*PM Consultant*
A	1	J	U
C	2	K	2
D	C	2	C
E	E	C	

Fig. 5.52 Short-list of candidate partners of each type

A lot will be learned about a PDM system from the vendor's reply to the RFP. However, even more information may be needed before the final choice is taken. The next step could be to ask for an in-depth demo of the candidate systems. This could result in the number of candidates being further reduced.

As a final step, the project team can create a benchmark script involving the most important and pertinent functions and features identified in the list of requirements, and ask the remaining vendors to demonstrate the scripted activities. Exactly the same test should be used for each system. The test should be typical of the work carried out by the company. The benchmark isn't carried out to provide a general evaluation of the system, but to test it for use in the company. The test should be prepared well in advance of the benchmark event, and should relate directly to the features that are of most importance for the project team. A scorecard can be created, and the scores noted for each activity for each vendor.

However, it may be difficult to simulate, in a benchmark, the real-life environment of multiple users, multiple systems, and very large volumes of data. For complex environments, benchmarking can be a difficult activity, and the results should be treated with caution. Poor benchmark performance may result from poor benchmark specification or a failure by vendor personnel to understand the project team's request. A benchmark of a system that is going to play a major note in managing product data is extremely difficult and time-consuming in view of the complexity, high volumes and multiple relationships involved.

As an alternative to benchmarking, or as an additional activity, the project team may decide to build a prototype solution in-house. This will probably involve some payment to the vendor, but will allow the project team to see in more depth how the system corresponds to requirements. It may also be possible to develop small PDM prototypes that users can run in everyday work.

In some companies, top management may insist that benchmarking and/or prototyping don't take place before decisions are taken about likely partners. In others, top management may feel that it's useful to have some practical experience of PDM before finalising the decision.

5.5.5.5 Identify Scenarios

Once the project team has completed the above steps, it should be in a position to identify several potential scenarios meeting the requirements. These should take into account not only PDM systems, but also financial and organisational aspects.

The system benchmark will probably have led to the elimination of some candidate PDM systems. As a result, only two candidate systems may remain (Fig. 5.53). It will be useful to investigate between three and six scenarios. The project team needs to describe each scenario in detail along with its strengths and weaknesses. This exercise helps gain an in-depth understanding. Often it's by trying to understand the strengths of a scenario that the weaknesses of other scenarios become apparent.

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
PDM System Vendor		A	A	C	C
System Integrator		1	2	C	2
OCM Consultant		J	2	C	K
PM Consultant		U	2	C	C

Fig. 5.53 Scenarios of systems and partners

5.5.5.6 Potential Benefits

The company expects the PDM system to help it meet business objectives. Now that the project team is close to making a final choice of system it should take another look at the expected benefits. The project team will know, from its discussions with top management, the business objectives on which it should be focusing. Typically, these will include reduced lead times, reduced product costs and improved quality.

It's important that the right measures of PDM performance are used to describe the potential benefits. The measures should be related to business characteristics and products, such as lead times, cycle times, number of engineering changes, number of parts, number of defects, cost of design and cost of production, and not to system characteristics, such as the number of users of the system, or the volume of data managed by the system. It's not easy to identify the most suitable measures. It's just as difficult to get agreement on them from top management, the project team, and the managers who will be judged against them.

The project team will need to show how the scenarios that it proposes meet the business objectives, and show how it will be possible to measure progress towards achieving specified targets. The identified needs will have to be quantified. How much would be gained from quicker response to customers? How much would be gained if people spent 10 % less time looking for information? What is the cost of not having an effective release procedure? How much would be saved if engineering changes were under control? How much would be saved if the number of administrative engineering staff could be reduced? What would be the saving from improved configuration control and traceability? What would be the benefit of synchronised engineering processes? How much would be saved by eliminating redundant data entry? How much could be saved by avoiding unnecessary transfer and conversion of data between systems? What is the value of improving security? What is the cost of unnecessary paperwork? What is the cost of bringing a product to market 1 month late? What is the cost of selling a low-quality product? What is the value of a longer sales window? What can be saved by reducing scrap and warranty costs? What is the cost of having to sell a product for less than the specified price? How much can be saved in Engineering, and how much in other functions?

5.5.5.7 Specific Benefits

Having understood the potential benefits of introducing the PDM system, the team should estimate the value of those that correspond to the business objectives.

5.5.5.8 Costs

The other side of the coin to the benefits is the cost of achieving them. The costs of the systems and their operation and maintenance, and other technical and organisational costs should be identified.

PDM system costs to be considered include not only those for purchase and installation of the system, but also new versions, expansion of the system, and interfaces to other systems. The total cost of a system over its expected lifetime should be understood, taking account of the cost of hardware and infrastructure, initial configuration and customisation, the cost of customising upgrades, and on-going support and maintenance costs.

Corresponding organisational costs should also be identified. These could include those for consulting, project management, organisational change management, implementation planning, training, development of procedures and documentation, system management and support, and potential changes in management roles and responsibilities.

5.5.5.9 Other Criteria

Other criteria to be considered in the scenarios include several related to the PDM system vendor. Among these are vendor commitment to PDM, the development plan, ability to develop and upgrade, maintenance record, growth record, user group, delivery time, and availability of technical assistance.

5.5.5.10 Roadmap and Plan

The project team should develop a high-level roadmap/implementation plan for each scenario. The implementation plan produced at this stage by the project team should address both the long term and the short term. For the long term, it provides management with the information necessary to understand the resources that the project will require. It shows the activities that will be required in related areas. It shows how the initial installation fits into a long-term development plan. The more specific the plan is, the better. It should define an overall implementation timetable showing how the implementation of PDM will be split into manageable projects. All companies are different, so each will have a different implementation plan which should be built up of manageable and prioritised sub-projects.

Many companies find that it's best to start by getting product data under control, and making sure it's clean. The next step is often to implement and populate the Information Vault. This will provide a basis for implementing release procedures.

In the next step, most companies will want to move on to three major activities. These are product structure management, engineering change management, and the integration of the PDM system with applications such as ERP.

The project is likely to be carried out in phases. As a result, there's usually a set of plans addressing different time periods. A top-level phase plan should show the entire project over its expected duration (Fig. 5.54).

Another plan will show the major tasks of the current phase (Fig. 5.55). The plan should be confirmed with top management before project activities start. Top management should be kept aware of progress, and of any problems that may arise.

The short-term plan should show management which actions will be taken in the short term. The plan is more likely to be accepted if it includes some actions that will lead to short-term savings and other short-term benefits.

5.5.5.11 Return on Investment

With the timing of expected costs and benefits known, the ROI can be calculated for each scenario. As the implementation of PDM is a long-term activity, the costs and

Phase Activity	*Y1*		*Y2*		*Y3*		*Y4*	
	H1	*H2*	*H1*	*H2*	*H1*	*H2*	*H1*	*H2*
Prepare Phase 1 (Design to Deploy)	■							
Execute Phase 1 activities	■							
Prepare Phase 2 (Use and Support)	■							
Execute Phase 2 activities		■	■	■	■	■	■	■
Prepare Phase 3 (Review and Breakeven)			■					
Execute Phase 3 activities				■				
Prepare Phase 4 (Evolve and Extend)					■			
Execute Phase 4 activities						■	■	■

Fig. 5.54 The planned phases of the project

Activity	*M1*	*M2*	*M3*	*M4*	*M5*	*M6*
Detail the plan for Phase 1 activities	■					
Manage the Phase 1 activities	■	■	■	■	■	■
Execute Detail Design and Plan activities	■	■				
Execute Build and Plan activities		■	■	■		
Execute Test and Validate activities					■	
Execute Deploy activities						■
Report Phase 1 activities						■

Fig. 5.55 The plan for the first phase

benefits will need to be worked out over a 5-year term. A discounted cash flow return on investment calculation will be appropriate.

5.5.5.12 Risks

There may be potential risks from many sources, not only technical but also organisational. The risks associated with each scenario should be identified and quantified.

5.5.5.13 Build the Scenarios

The scenarios can now be compared (Fig. 5.56) taking account of costs, benefits and risks.

5.5.5.14 Prepare and Present the Scenarios

The project team needs to understand, and to be able to communicate, the major differences between the scenarios from the business point of view. This is a high-level message it will give to top management.

5.5.5.15 Select the Partners

In different companies, this activity will take place in different ways. In some cases, top management will want to examine the scenarios in detail and then take the decision. In other cases, the project team will be free to take a decision which top management will then review.

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Benefits		5	4	3	3
System Costs		1	1	3	3
Organisational Costs		1	1	2	1
ROI		4	4	3	3
Risk		1	1	4	3
Other		3	3	4	4
Total Score		15	14	19	17
Final Ranking		3	4	1	2

Fig. 5.56 Result of scoring the scenarios

5.5.6 Pre-align with Your Partners

The objective of this step is to get high-level alignment and agreement within the company, and with partners. By the start of this step, the company knows which PDM system it wants and with which partners it will work. Next it wants to sign contracts and start working. However, before doing so, it will have to meet with the partners, explain to them what has been decided, and clarify the next steps.

During the pre-alignment phase, the activities of each partner are detailed in Statements of Work (Fig. 5.57). Contracts are prepared.

A Statement of Work (SOW) is a document that defines the work, deliverables and timeline of a particular activity. Statements of Work are written to define the work to be carried out by the vendor of the PDM system or by a service provider. However, some companies also write them to clarify work that will be carried out by specific groups within the company. An SOW can address many working terms and conditions including requirements, scope, phases, acceptance criteria, price, payment schedule, and deliverables schedule.

After the RFPs were sent, as a result of various proposals, the company may have made some minor changes in its requirements. These will have to be discussed with the partners. Depending on the exact constellation of partners, some changes in the scope of activities of each may be needed. And there may be some changes in the dates in the project plan compared to the project dates proposed in the RFP.

When the details of the contracts and Statements of Work have been agreed, the company and the partners will sign them.

5.5.7 Align and Plan with Your Partners

By the start of this phase, the company and its partners will have signed contracts and SOWs. However, although the partners will have described what they intend to do in the project, they won't have actually started work. They will have invested time in talking to the project team, in describing their activities, in writing the proposal, and in discussing SOWs and contracts. However, they won't have started doing any project activities. This is normal. Until contracts were signed it wasn't 100 % sure what they should do. And as contracts hadn't been signed, they wouldn't have been paid for anything they did.

requirements	project schedule	project phases
project scope	costs	acceptance criteria
PDM system vendor role	benefits	deliverables
service provider role	value	payment

Fig. 5.57 Subjects to clarify in the statements of work

It's only now that contracts have been signed that work can start. As a result, there's now a phase in which the pre-aligned agreements have to be reviewed and detailed. The alignment defines in detail the work to be carried out in the Detailed Design, Build, Test and Deploy phases.

5.5.8 Carry Out Detailed Design and Planning

At the beginning of this step, the company and all the partners have agreed what has to be done. And there's a detailed plan showing when it should be done. This step has two objectives. The first is to design in detail all the parts, or units, that will be needed to deploy a successful PDM system. The other is to create a more detailed plan showing how these parts will be built, tested and deployed in the following phases.

The output at the end of the step includes the design specifications and more detailed plans for following phases. The required resources and risks are known for each activity. The design specifications will show, in detail, how the PDM system will be configured and customised.

There's a lot to do in this step (Fig. 5.58). The potential states of data need to be defined (e.g., initial user development, in-process, in-review, released, under revision, withdrawn) for each data element. Data ownership issues must be resolved, and the rights and responsibilities defined for both the owners of private data, and the administrators of shared data. Access, security, collection, quality, maintenance and documentation issues must be resolved for both types of data.

5.5.9 Build and Plan the PDM System

By the beginning of this step, the detailed design has been completed. The objective of this step is to build, adhering to the design documents, all the parts, or units, that will be needed to deploy successfully the PDM system. This is usually the largest step, containing many tasks (Fig. 5.59).

detail the PDM system architecture	clarify access rights
create the design specifications	detail the test strategy and plans
detail any required system configuration	detail the training strategy and plans
detail any required customisation of the system	detail the data migration strategy and plans
detail any required interfaces	detail all use cases
detail the required data model	hold user workshops
detail any required forms	develop prototypes
detail reporting requirements	identify the users of the PDM system
detail workflows	update the plan/roadmap for next steps
detail the objects in the PDM system	manage the project
detail the object lifecycles	define required PDM system policies
define system administration needs	define required PDM working procedures

Fig. 5.58 Tasks of detailed design and planning

configure system according to design	develop user documentation	build workflows
build the data model	develop working procedures	develop interfaces
configure forms	clean up data	carry out unit testing
configure reports	build data migration tools	develop prototypes for user review
customise software as detailed	build data migration scripts	update plans for next steps
develop any new software	build test scenarios and scripts	manage the project
develop training material	build user profiles (roles, rules, rights)	hold project progress meetings

Fig. 5.59 Tasks in build and plan

5.5.10 Test and Validate the PDM System

The objective of this step is to test and validate that all the parts, or units, built in the previous step, work together prior to deployment (Fig. 5.60). Test scenarios are run, issues identified and resolved.

In parallel, training is provided for users and system administrators.

5.5.11 Deploy the PDM System

The objective of this step is to put in place a fully operational system for users. Main tasks include deployment and migration (Fig. 5.61).

In parallel with these activities, training is provided for users and system administrators.

5.5.11.1 Go-Live

Go-Live occurs after successful deployment of the PDM system.

install and test the system environments	carry out system performance tests/tuning
carry out unit tests/full system tests	carry out user acceptance tests
carry out import/export data migration tests	update plans for next steps
carry out disaster recovery tests	manage the project

Fig. 5.60 Test and validation tasks

deploy the production system	deploy interfaces
carry out data migrationactivities	update plans for next steps
deploy support services	manage the project

Fig. 5.61 Deployment tasks

5.5.12 Use the PDM System

The initial use phase of the PDM project may be run under the overall authority of the project team, but an increasing proportion of work and responsibility should be given to the managers and users who have to use the system that has been implemented.

However, the project team must retain responsibility for key issues such as the project plan and budget, performance, interdepartmental reorganisation, and training. One of their major responsibilities at this time is to make sure that the implementation takes place within the agreed budget and time limits. This is a testing time for the project team. Everything they have done so far will be to no avail unless real benefits are now produced for the company and for users.

5.5.13 Support and Sustain the PDM System

Although initial use of the PDM system may appear to some people as the end of the project, it's actually only the beginning of the use of PDM to produce business benefits.

The initial deployment of the PDM system may only have been for a small number of users, or just one of many sites, or to support just one business process. During this step (Fig. 5.62), the deployment scope may be broadened.

5.5.14 Review PDM System Performance

Once the PDM system has been in use for a year, it's important to review its progress. There are several reasons for reviewing performance (Fig. 5.63).

It's only too easy for management to agree to a large investment in a PDM system. And then, faced with everyday fire-fighting activities in other parts of the company, forget about the project, assuming subconsciously that it's making good

get user feedback	monitor system use
deploy to remaining sites	implement new versions of the system
provide on-site and hotline support	resolve system issues
provide on-going user training	update plans for next steps
maintain the system	manage the project

Fig. 5.62 Support and sustain tasks

make progress towards targets visible	find out what worked well in the project
identify any slippage between plans and reality	find out what didn't work well
learn from experience to avoid repeating mistakes	find out what could have worked better
put the project back on the right path	document lessons learned

Fig. 5.63 Reasons for reviewing PDM system performance

progress against plan	problems	improvement suggestions
progress towards benefits	number of users	next steps
achievements	lessons learned about PDM	KPIs
costs (actual vs planned)	risks and issues in the project	user experience

Fig. 5.64 Contents of the performance review report

progress. The objective of this step is to formally evaluate progress towards the targeted objectives and benefits. A report will be issued to management, and appropriate actions will take place (Fig. 5.64).

5.5.15 Achieve Breakeven for the PDM System

A PDM system project can only be considered to be successful once the system has been in use long enough for the benefits it produces to exceed its costs. That may take a long time. Starting from the time that people in the company first show interest in PDM, it may be several years before the costs are recovered.

5.5.16 Evolve and Extend the PDM System

The objective of this step is to identify and implement improvements and extensions to the PDM system. A continuous improvement approach should be taken. Each year, for example, use of the system can be reviewed and potential improvements identified. A list of potential requirements, along with their costs and benefits, can be proposed to the Steering Committee for approval.

5.6 Learning from Experience

PLM applications are addressed in many PLM Initiatives. From experience with many companies, lessons can be learned about success and failure.

5.6.1 From the Trenches

5.6.1.1 Process Before System

We started working with a company some way through its PLM Initiative. The project was in a phase where the main focus was the implementation of a PDM system that had been selected in a previous phase. To understand requirements better, the company started looking at the business processes. After defining new processes, the company saw that the system didn't meet its needs. It looked for, and found, another PDM system that corresponded better to its needs.

5.6.1.2 Faraway

The company had several BUs, one on the Head Office site, the others in different countries. Each BU had a different CAD system. A team made up of members from all the BUs had been given the job of selecting CAD and PDM systems for the future. They asked us to provide some neutral, external help. We got the team to look at the as-is situation, including business processes and applications. We got them to look in company and BU plans to see how the company wanted to work in the future. The team then made a proposal for a common CAD and PDM solution worldwide. The selected CAD system was already used by some of the BUs, but not on the Head Office site. The PDM system selected by the team was from the same vendor as the CAD system. The team presented their report to top management. The company president, who hadn't been available for discussion with the team, said the team was faraway from reality, and the company would implement the CAD system being used at the Head Office site.

5.6.1.3 PDM Is for the Lifecycle

A manufacturer of high-tech machines asked me to help with selection of a PDM system. As a first step, they wanted to map the design and manufacturing processes. Their HQ was far from my home. By chance, in a restaurant one evening, I met one of their service engineers who was attending a quarterly meeting. We got talking. He told me he was on the road every week fixing problems. The customers wanted customised products, but the company didn't have the systems to make sure all the parts for a specific order fitted together. What worried him even more was that, when he filed an error report about a part, it took more than a year before the problem was fixed. During that time the plant went on making the wrong parts. Logistics delivered them to customers, and he had to go and fix them and pretend he didn't know what was wrong. I got the company to extend the process mapping activity in the PDM system selection project to look at the whole product lifecycle including installation, maintenance and end-of-life.

5.6.1.4 So That's What We Do

The new manager of Engineering IS in an aerospace company asked me to help them select their new CAD system. He had been in another department of the company for about 20 years, but had not been involved previously with CAD. I told him we should identify all the creators and users of CAD data, and understand their requirements. It soon became clear that the previous manager of Engineering IS had only been interested in a small area of CAD. About 90 % of the potential users had been neglected. As I talked to the users, I created a model of the flow and use of engineering information. I included this as an appendix in the final report. On one page of the model was an overview. It showed the flow starting with the requirements for a new aircraft, going through design, and ending with production. The next three pages had the details for requirements management, design and production.

A presentation was made to the Board, and they accepted the conclusions of the report. After the presentation, as I was leaving, I just had time for a few words with the Engineering IS manager. He didn't say anything about CAD. He just said, "Thank you very much for the appendix. It's helped me a lot. I've been here more than 20 years, but until now I've never understood how we go about making a new aircraft".

5.6.1.5 A Clean Slate

There was an unusual reason for an assignment with a company of less than 100 people. The CAD Manager had been unhappy with the lack of recognition of his efforts in implementing and supporting a CAD system over several years. As a result, he left. But not before deleting all the CAD files. And the backup files. It was a good reminder that PLM isn't just about technology.

5.6.1.6 Now I Begin to Understand

Sometimes it's not easy for people who aren't directly involved in everyday work to understand the corresponding issues. In one company, it wasn't until we showed the contents of Fig. 5.65 to one of the managers that he understood how difficult it was for engineers to keep track of file names.

5.6.2 Guidelines for PDM System Implementation

In many PLM Initiatives there's a project to implement a PDM system. As a result, it's possible, from experience, to identify some guidelines for PDM system implementation (Fig. 5.66).

5.6.3 Pitfalls of Application Implementation

Implementation of a PDM system is a frequent activity in a PLM Initiative. From experience of working with many companies, lessons have been learned. Many

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Directory: truck.glass43
Glass1.model4.x11.ds8 1940 12-07-10 ww r
Glass1.model4.x13.ds8 2218 12-11-10 ww r
Glass1.model4.x14.ds8 2034 12-12-10 ww r
Directory: truck.glass44
Glass1.model1.ds8 920 12-12-10 ww rw
Glass1.model2.ds8 950 12-12-10 ww rw
Glass1.model4.ds8 1046 12-14-10 ww rw
Directory: truck.roof43
Abeam1.right1.try1.ds8 245 01-01-11 hk r
Abeam1.right1.try2.ds8 235 01-05-11 hk rw
Abeam1.right1.try3.ds8 254 01-05-11 hk r
Abeam1.right1.try5.ds8 234 01-03-11 hk rw
Abeam1.right1.try7.ds8 244 01-08-11 hk r
Abeam1.riqht1.try8.ds8 254 01-05-11 hk rw
Front1.riqht1.try1.ds8 483 01-01-11 rj r
Front1.right1.try2.ds8 485 01-01-11 rj r
Front1.right1.try3.ds8 486 01-02-11 rj r
Front1.right1.try4.ds8 487 01-03-11 rj r
Front1.right1.try5.ds8 483 01-04-11 rj rw
Front1.right1.try5.ds8 495 01-03-11 rj r
Front1.right1.try9.ds8 476 01-04-11 rj r
Front1.right1.trya.ds8 509 01-05-11 rj r
Glass1.bills1.ds8 2034 12-12-10 ww r
Blend1.my1.try1.ds8 532 01-10-11 rj rw
Blend1.my1.try2.ds8 603 01-12-11 rj rw
Blend1.my1.try5.ds8 552 01-15-11 rj rw
Blend1.my1.try6.ds8 623 01-12-11 rj rw
Blend1.my1.try7.ds8 562 01-12-11 rj rw
Blend1.my1.try8.ds8 673 01-11-11 rj rw
Blend1.my1.try9.ds8 663 01-12-11 rj rw
Blend1.my1.trya.ds8 662 01-12-11 rj rw
Blend1.my1.tryb.ds8 623 01-16-11 rj rw
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Fig. 5.65 File names in file-based data management

define the objectives of the PDM project very clearly
make sure the objectives are oriented towards use of PDM
include users in the project team
select a project leader who can handle the cross-functional aspects of PDM
commit the project leader for the long term
create a realistic project plan
judge the project leader and the project team on the results of PDM system use
calculate how much money the system will generate and how much it will save
focus the project on use of PDM, not on the selection process
don't let people think the project ends once a PDM system has been chosen
expect user resistance to change
aim for productive use of PDM
simulate the environment of productive use of PDM

Fig. 5.66 Guidelines for PDM system implementation

not having executive support for the project	not measuring and promoting PDM success
not having clear PDM project objectives	not believing the PDM system is just one component of success
not managing project risks	not planning to overcome setbacks and rejection
not educating top and middle managers	not involving everyone across the product lifecycle
not believing 50% of similar projects fail	not being aware of the initial state of product data

Fig. 5.67 Pitfalls of PDM system implementation

no executive involvement	no knowledge of integration costs
no involvement of users in selection	no knowledge of maintenance costs
no business objectives	no plans or targets for use
no business case	no user made responsible
no review of existing PLM applications	no training for users

Fig. 5.68 Pitfalls of PLM application implementation

potential pitfalls have been seen in PDM system implementation (Fig. 5.67). Knowing about them is a first step to avoiding them.

PLM applications are implemented in many PLM Initiatives. From experience, there are many pitfalls waiting for those implementing PLM applications (Fig. 5.68). Knowing about a pitfall helps to avoid stepping into it.

5.6.4 Top Management Role with PLM Applications

5.6.4.1 Provide Vision and Leadership

Unless top management is involved, there's a danger that applications will become a victim of the general lack of vision and co-ordination that many companies exhibit towards IS. Information Systems have become a tool with which a company can gain competitive advantage. They have become an important component of company strategy. During the company strategy development process, account should be taken of the possibilities IS can offer in helping to meet the corporate goal of providing optimum products and services to customers. PLM must be seen as part of the overall IS strategy. It can't take its rightful place if top management is unaware of its existence and potential. Top management needs to ensure the appropriate organisation of IS, and its relationship with the rest of the business.

5.6.4.2 Involvement with PDM

When a PDM system is introduced, there may be great pressure to install it and get it working as cheaply as possible. This can be expected to lead to minimum, or zero, investment in the organisational aspects and, a few years later, the realisation that the system is not fulfilling its initial promise. To avoid this unfortunate result, top management must be involved in the early stages of introducing PDM, and make it clear that the initial objective is not to select the solution that appears quickest and cheapest. Instead, top management must ensure that the decision takes full account of the company's PLM objectives, the roles of PDM and PLM in the future, and the organisational actions that must be taken for an apparently technological solution to be used successfully.

5.6.4.3 A Strategy for PLM Applications

Top management should ensure that there's a strategy for PLM applications. Without such a strategy there will be chaos and waste. IS policies and standards are also needed.

5.6.4.4 Clarify the IS Role

Top management needs to make sure that IS professionals understand their role in PLM. They're not just expected to acquire and provide applications. They also need to participate in helping the company transition to the new PLM paradigm.

5.6.4.5 Communication

In a PLM project, a gap can emerge between IS and the rest of the business. Top management should make sure this gap doesn't occur. Communication plays a key role.

5.6.4.6 Vendor Control

Top management needs to make sure that the IS organisation ensures that application vendors provide the products and services required by the company. Top management needs to avoid the situation in which the IS organisation and the application vendors are on one side, and the rest of the company is on the other side.

5.6.4.7 Budget

Top management needs to provide the funding for acquiring and supporting the IS resources needed for PLM.

Chapter 6
Organisational Change Management in the PLM Environment

6.1 This Chapter

6.1.1 Objective

The objective of this chapter is to give a basic introduction to organisational change and Organisational Change Management (OCM) as they relate to a company's PLM environment and PLM Initiative. This introduction will help those in a company's PLM Initiative to understand change-related topics and participate more fully in the PLM Initiative. The chapter also aims to give students a basic understanding of the role and activities of Organisational Change Management in the PLM environment.

6.1.2 Content

The first part of the chapter is an introduction to Organisational Change Management (OCM) in the PLM environment. It describes the purpose, role and importance of OCM in a PLM Initiative. Definitions are given of frequently used terms in the OCM environment. The need for OCM is introduced. Required characteristics of organisational change, including KPIs, are outlined.

The second part of the chapter focuses on the people in the PLM environment. Some try to bring about change, some are expected to change.

The third part of the chapter addresses OCM in the PLM environment of a typical company. It describes typical issues that are encountered in many companies. The interaction of OCM with the resources of PLM and with other company initiatives is addressed.

The fourth part of the chapter describes typical projects in the PLM Initiative that are related to organisational change. Examples of change-related projects are given.

J. Stark, *Product Lifecycle Management*, Decision Engineering,
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The fifth and final part of the chapter builds on experience of working with organisational change with many companies. It shares lessons learned from experience of OCM in PLM Initiatives. The potential pitfalls of OCM are described. Top management's role in the management of organisational change is addressed.

6.1.2.1 Skills

This chapter will give students, who've been assigned this book, a basic understanding of Organisational Change Management in the PLM environment. They'll learn why it's important. They'll be able to explain, communicate and discuss about organisational change, OCM and related activities in a PLM Initiative. And they'll be aware of some companies' experience with OCM sub-projects in PLM Initiatives.

For more information about OCM, students should read *Leading Change* (Kotter, John P., 1996, Harvard Business School Press, ISBN 978-0-87584-747-4).

6.1.3 Relevance of OCM in PLM

A PLM Initiative usually results in many changes being proposed (Fig. 6.1). The proposed changes will probably address all the components on the PLM Grid (Fig. 1.5). The changes will affect the way people work. For example, an improved New Product Development process will be executed by many people. They'll have to understand and adapt to the changes. Similarly, a new product data structure will be used by many people. They'll have to learn about the changes and work differently. New roles and responsibilities in the Engineering Change Management process will impact many people, and will change the way they work.

However, it's difficult for companies and people to change, whether it's because of PLM, or because of another reason. Many people don't like to change. They have quite legitimate fears and concerns about change. They prefer things to stay as they are. However, if the changes don't occur, the objectives of the PLM Initiative won't be met. In the absence of OCM, many PLM Initiatives fail because the expected changes don't take place.

To avoid failure, it's important to identify and carry out activities to help change take place. Getting people to change is a major issue. Achieving success requires

processes to be improved	new applications to bring in
old tasks to modify	product data to be structured and used differently
new tasks to identify, define and improve	cultural problems to address
people who will have to change	organisational structures to change
new documents to be used	new roles and responsibilities to be introduced

Fig. 6.1 Common changes in a PLM Initiative

the application of "tools for change" such as learning, leadership, communication and the right reward systems.

If you want your PLM Initiative to succeed, it's not enough to propose changes. You also have to make the changes happen. This is where Organisational Change Management (OCM) comes in, and why it's one of the five pillars of PLM.

6.2 Definitions and Introduction

6.2.1 Definitions

6.2.1.1 Organisation

From a PLM point of view, the organisation of a company describes the way it structures its resources to manage products across the lifecycle. These resources are shown on the PLM Grid (Fig. 1.5).

6.2.1.2 Organisational Change

Organisational Change occurs when a company changes from one organisational structure to another.

6.2.1.3 Organisational Change Management

Organisational Change Management is a structured approach, involving several Organisational Change activities, which accompanies and supports a company as it proactively changes from its existing organisational structure to a clearly-defined future structure. The objective of OCM is to successfully achieve this change.

Typical Organisational Change activities include aligning expectations of change, communicating about change, clarifying new job descriptions, developing new recognition and reward systems, planning, training, coaching and mentoring.

To avoid chaos and failure, the many change activities have to be planned and managed.

6.2.1.4 Organisational Change Plan

The Organisational Change Plan is a plan of the required change activities and projects. It defines in detail which activity will be carried out at what time, by whom, and with what resources. It shows the links between activities.

Each Organisational Change Project, like any other project, needs a well-defined objective, clearly defined deliverables, a project team, a project manager, a project plan, and project phases.

6.2.2 Benefits of OCM

Many changes are proposed in a typical PLM Initiative. However, it's difficult for companies and people to change. But if they don't change, the objectives of the PLM Initiative won't be met.

Organisational Change Management accompanies and supports the overall organisational change. Its objectives are to make sure the change is successfully achieved and the objectives of the PLM Initiative are met. OCM aims to bring benefits both to the company (Fig. 6.2) and to the people in the company.

OCM aims to support the individual employees who will be impacted by the targeted changes (Fig. 6.3). They will have to change from their current way of working to the future targeted way of working.

6.2.3 Incremental and Transformational Change

There are two approaches to change, incremental change and transformational change. Incremental change (Fig. 6.4) is aimed at making many small-scale improvements to current business processes. It focuses on small-scale improvements

motivates everyone to achieve the targeted objectives	lowers the risks of change
helps to align change resources	anticipate challenges
maintains organisational effectiveness and efficiency	contains the costs of change
reduces the time needed to implement change	enables development of best practices for change
reduces the possibility of unsuccessful change	plans involvement of the right people at the right time

Fig. 6.2 OCM benefits for the company

smooths the transition from the old to the new	reduces stress
support for concerns regarding changes	increased employee acceptance of the change
ensures that stakeholders understand and support the change	includes tasks for each person
improves cooperation, collaboration and communication	emphasises positive opportunities
personal loss/gain to individuals is acknowledged and addressed	correct perception of the change

Fig. 6.3 OCM benefits for individuals

doesn't challenge existing assumptions and culture	is relatively low-risk
doesn't modify the existing organisation	is slow
uses existing structures and processes	may not produce enough change
causes little disruption	has a predictable outcome

Fig. 6.4 Characteristics of incremental change

changes existing structures	is relatively high-risk
changes the existing organisation	is fast
changes the existing culture	focuses on major breakthroughs

Fig. 6.5 Characteristics of transformational change

organising activities so they meet the objective, and don't just mimic the current tasks
treating geographically dispersed resources as though they were at one location
melding parallel activities together instead of integrating their results
putting the decision point where the work is carried out
building control and feedback into the process
getting those who use the output of a process to perform the process
including information-processing work in the information-producing work
capturing information once, at the source

Fig. 6.6 Basic principles of transformational change

because experience shows the likelihood of succeeding with a small-scale improvement is much higher than that of succeeding with a large-scale, strategic improvement project. If everyone makes small-scale improvements to the parts of the business they know well, the end result should be major improvement. It's often the case that, taken individually, local improvements of this type have no effect on the overall business. However, many small improvements snowball and can result in a major improvement in overall performance.

From the viewpoint of the company, the expected overall improvement resulting from this approach is incremental, small-scale, almost invisible, and difficult to measure. The incremental approach is rarely suitable for a PLM Initiative.

Transformational change (Fig. 6.5) involves radically rethinking and redesigning a major business process with the objective of achieving large-scale improvements in overall business performance. The product lifecycle is a prime target. The product lifecycle runs across many of the traditional business functions, and has a high degree of customer and supplier involvement.

Transformational change (Fig. 6.6) fundamentally changes the way a company works. It changes the way processes fit together, changes the way people work, and changes the way that IS applications fit together. This is what's needed for PLM, but it's hard work.

The end result of a transformational change is very visible, so easy to measure. As a result, a well-defined business case can be developed for PLM under this approach.

6.2.4 Equation for Change

For mathematicians, the equation for change is easy to write:

$$(\text{New state}) = (\text{Change matrix}) \times (\text{Old state})$$

Current Situation	*Y(1)*	*Y(2)*		*Y(n)*		*Vision*
Surroundings						Surroundings
Product						Product
Customer						Customer
Organisation - extended						Organisation - extended
Business processes						Business processes
Organisation - internal						Organisation - internal
People						People
Product data						Product data
Working methods						Working methods
Applications						Applications

Fig. 6.7 Many intermediate change states

At first sight, it might seem that there's just one old state (also known as the current situation, or the as-is situation) and one new state (also known as the to-be situation, or the vision).

However, there are also an infinite number of intermediate new states between the old state and the new state (Fig. 6.7). For example, the state after 1 year and the state after 2 years. Rather than just thinking about as-is and to-be states, it's important to think about the intermediate states, because in the real world, this is where the change project will spend most of its time.

The intermediate states are continually changing. They're a bit like shifting quicksands. They're not pleasant places to be. Yet this is where people spend most of their time in a change project. Understandably, most people don't like it. They want to know if there will be any solid rocks to walk on during the change. And where they are? And just how far away is the solid ground on the other side?

The old and new states can be defined with reference to the components of the PLM Grid. The change may affect the products delivered to customers, business processes, people, product data, methods and PLM applications. A major change project aimed at completely changing the focus of a company will address all these components. Projects of more limited scope will only address some of them.

6.2.4.1 Many Overlapping Changes and Change Projects

A typical OCM sub-project in a PLM Initiative will include many change projects and many changes. Some may overlap, making them difficult to plan. In the example (Fig. 6.8), the four change projects (CP1, CP2, CP3, CP4) overlap. Some of the planned changes (e.g., B and D) require coordination between different projects.

	Change Projects	CP1	CP2	CP3	CP4
Changes					
		A			K
		B	E	B	
		C	F	G	
		D	D		
			J	H	
				I	L

Fig. 6.8 Overlapping change projects and changes

6.2.5 Resistance to Change

There are many reasons (Fig. 6.9) why it's difficult for companies and their people to change. Some of these have their source in the company's structure and way of working, others in its culture.

6.2.5.1 Employee Issues

In a large company, it's going to take a long time and a lot of effort to bring about change. Top management may feel the need to change, make the right decisions, and set the right targets. But unless the great mass of the company's employees change, then nothing's going to happen.

Most people are going to have change thrust upon them. They will be "the targets of change", "the victims of change", "the people to be changed". However, most of these people will be quite happy with the current state of things. They may complain a lot about the current state, and about their managers and colleagues, but they do accept the current state and live with it. They're quite happy to do tomorrow what they do today and did yesterday. They consider that normal. They don't want to change and step into the unknown. Someone, however, would like to change this stable, generally accepted environment. Among themselves, the potential victims of change will be talking about the changes (Fig. 6.10).

Bringing about change in a company, in which many people may feel as if their world is falling apart, and they're doing all they can to hang on for dear life, isn't easy. It's not easy to persuade people to stop doing the things they've succeeded with over the last 5, 10 or 20 years and instead work in a different way.

attachment to the old way of doing things	concerns about competence	not being informed
feeling good about known routines	bloated with change	fear of job cuts
seeing no benefits from change	fear of the unknown	lack of trust
waiting for the storm to pass	not being involved	fear of fads

Fig. 6.9 Reasons for resistance to change

"why should I change?"
"this company has made me do the same thing for the last 10 years and now it asks me to change because apparently that was the wrong thing to do. After 10 years of doing it one way, how can you expect me to change and do it another way?"
"every few years there's a great new idea from on high, and we're all supposed to change. One year it was quality circles, another time it was Customer Focus, and of course, recently it was Lean. After a few months, those programs always faded away, and everything went back to normal. Except the people who participated very visibly were usually in deep trouble because someone had to take the blame. Why should I put my head on the block for PLM? As they got it wrong before, who's to say they've got it right now?"

Fig. 6.10 Remarks of potential victims of change

6.2.5.2 Management Issues

Managers may have similar issues with changes as other employees. In addition, they can have their own specific management issues.

Major changes can only happen if top management takes the lead, yet top managers may not be capable of taking the lead in a particular environment. They may have performed excellently when things were going well and smoothly for the company, but not have the skills to lead the company through a period of change.

It can be expensive to change. Downsizing the payroll, or taking people off activities that generate revenues in the short-term, can lead to quarterly results looking sickly for quite a few quarters. That can wipe out management bonuses.

In a large company, it's going to take a long time and a lot of effort to bring about change. For a large company, it may take 5 years for the real results of the change to come through. That's a long time for a top management team to maintain focus and involvement. It will be tempting for some of the team members to look for easier ways to glory.

Change is difficult, time-consuming and costly. It offers huge benefits. As they try to change, some managers may get caught in the trap between fear and greed. They'd like to have the benefits of change, but they're afraid of failure. So they try for low-cost, high-value change, exhorting everyone to do their best. Everyone nods their heads in agreement, and then goes away and does whatever they were doing before. And change doesn't happen.

6.2.5.3 General Issues

Many people in a company will understand why PLM is important. They'll be able to see where it can help, and what benefits it can bring. Unfortunately, there will also be many people who won't understand the need for PLM. Those who may have difficulty in understanding the need for PLM could include the CEO, top managers, product development managers, product support managers, engineering managers, quality managers, human resource managers and IS professionals. Figure 6.11 shows possible reactions to talk of PLM.

- we're focusing on customers these days, not products. Customer focus is our message
- we're focusing on being Lean these days, not on products
- PLM is another enterprise-wide mega-project. Everyone knows that kind of project doesn't work
- since the global financial crisis, we focus on cost-cutting, we don't look for ways to spend money
- the payback period is more than 12 months, so our CFO won't be interested
- get Engineering to do its job properly, and you won't need PLM
- get Marketing to define specifications properly, and you won't need PLM
- we don't need it. We have ERP
- we don't need it. We just put a new product support organisation in place
- we've done it. We have a product knowledge data base
- we've done it. We already have a PDM application
- we've done it. We already have a PLM application
- talk about it with the CIO. It's his responsibility, not mine
- talk about it with the Engineering VP. It's his responsibility, not mine
- we don't believe in Three Letter Acronyms (TLAs). No more acronym soup here
- it's early days for PLM. Come back in 5 years
- we've had enough of enterprise applications. We're trying to simplify before automating
- PLM isn't an application issue, it's cultural. You can't buy it. Shrink-wrapped or otherwise
- I understand the need for PLM. But there's no support from top managers, so it doesn't interest me
- we don't have the technical and management skills to implement PLM
- why worry about technical details of our products? We'll just change peoples' perceptions of them
- I know my boss is interested in PLM, but he doesn't know how to justify its cost, so isn't pursuing it
- enterprise-wide PLM is difficult to implement and has a high failure rate. I don't want that risk
- we have one guy who manages all our technical computing. There's no way he can do PLM alone
- NIH. We don't want it. It wasn't invented here, so isn't worth having

Fig. 6.11 Different reactions to PLM

6.2.6 Prerequisites for Organisational Change

When companies are faced with a major product development project they'll make sure they've a well-defined objective, clear specifications, a project team, a project manager, a project plan, project phases and test plans. The same approach has to be taken for a PLM Initiative. If it's expected to have a significant effect on the company, a change project is needed. Change is an activity in its own right. It has to be defined, planned and managed. For successful implementation of change, certain conditions must be met (Fig. 6.12).

Major changes can only happen if top management takes the lead. Massive change in a company isn't going to be brought about by one person half way down the organisation chart. It's not enough for one executive to want to change, the whole top management team has to be on board. It only takes one person to drag their feet and the momentum will start to drain away.

a strong and widely agreed desire for change	widespread awareness of the reasons for change
recognition at the top of the need for change	a motivating vision of the future after change
top management commitment to change	plans to overcome resistance to change
a single, unchanging theme for change	changes to the reward and recognition system
a plan for change activities	a change leader

Fig. 6.12 Conditions for successful change

6.2.7 KPIs for Organisational Change

A Key Performance Indicator (KPI) is a quantifiable attribute of an entity or activity that helps describe its performance. It's something that can be measured to help manage and improve the activity. KPIs of change help a company to set targets for its change activities and to measure the progress that it's making (Fig. 6.13). For each KPI there's a current value and target values for the future.

6.2.8 The Importance of OCM in the PLM Environment

A PLM Initiative is a change initiative. It's expected to improve performance. A performance improvement is a change.

6.2.8.1 Special Features of OCM in a PLM Initiative

Without an OCM sub-project, the PLM Initiative is unlikely to achieve its objectives. However, it's often difficult to get the people in a PLM Initiative to understand and accept this. There may be several reasons for this. Many people in the Initiative will have technical backgrounds and be believers in hard facts. They may not be so keen on "soft" issues like OCM. Many people in the Initiative will be IS specialists, and assume that success will come from new applications, not from talking about change. Other IS specialists in the Initiative won't understand why "change gurus" are interfering with testing and Key User activities.

It can also be difficult to find experienced OCM specialists who can work in the PLM Initiative. PLM is a relatively new subject and there's a shortage of "change practitioners" with experience of PLM. And because the scope of PLM is very wide, it can be difficult for "change practitioners" without experience of PLM to get their arms round it.

6.2.8.2 Results of Ignoring OCM in a PLM Initiative

Many PLM Initiatives fail. Some sources cite failure rates as high as 50 %. Failure is rarely due to individual processes or applications. Usually it's due to the way that they're implemented. It's often assumed that, without any support, people will switch overnight from the tools they've been using for years to something

number of change goals achieved	number of failed changes	disruption time	disruption cost	value added

Fig. 6.13 Some KPIs for change

people will resist the changes	the Initiative's business objectives won't be met
new IS applications will be underused	the Initiative Leader will be punished
there will be confusion about what to do	supporters of the Initiative will be punished
top management will be unhappy	Initiative team members will leave the company, or be punished

Fig. 6.14 Typical consequences of ignoring OCM in a PLM Initiative

completely new. In theory that may seem realistic, but in practice it doesn't work, and the likely consequences are clear (Fig. 6.14).

6.3 Participants in Change

In many companies, more than 20 % of employees will be impacted by the changes resulting from a PLM Initiative. A lot of people will be affected by the change.

6.3.1 Benefits of the Change to PLM

PLM impacts everyone whose job in some way relates to the company's products and their performance. PLM maximises value, reduces risk, and provides an integrated view of what's happening with the company's products at all times. With such promise, it's of interest to all. However, the benefits of PLM are seen differently by different people.

At the highest level, the Chief Executive Officer (CEO) expects PLM to increase revenues and earnings by bringing better products to market faster, and extending the lives of mature products. CEOs look to PLM to provide visibility and control over products, ensuring that there are no unwanted surprises. CEOs look to PLM to maximise product value over the lifecycle, to maximise the value of the product portfolio, and to reduce risk.

With PLM, the Chief Financial Officer (CFO) can see the real financial figures for a product across its lifecycle, so knows precisely how much it has cost and earned. Costs can be reduced as activities that don't add enough value become more visible. Better estimates can be made for the real financial figures related to developing and supporting each product in the future. With uncertainties reduced, more reliable financial projections can be made.

PLM provides the Chief Information Officer (CIO) the opportunity to carry out a wide range of necessary activities to clean up the company's product-related processes and data. These will solve many everyday problems that currently occupy the time of IS professionals. This will lead to a reduction in IS costs and a redirection of IS effort to activities that add more value. With PLM, the CIO can align IS applications to help bring competitive products to market faster and to support better their use.

PLM gives Product Managers an integrated view over their products and their product development and support projects. The exact financial and technical status of every part, product and project is known. With better information available, it's easier for them to take account of potential product and project risks. Product Managers can make decisions based on reality. Unwanted product-related costs, resulting from rework and scrap, warranty and liability claims, and returns and recalls will be reduced, and then eliminated. The Product Manager can take control, both during product development and at later stages in the product lifecycle. The Product Manager can develop and implement strategies for faster development and introduction of new products, and for better support of products across their lifecycles.

PLM helps Marketing Managers make better and faster responses to Requests For Proposals, and re-use material from successful proposals. It helps them to price proposals realistically and competitively. It helps get better feedback about product use. With all the product data and customer specification information available, it will be much easier for Marketing Managers to evaluate future opportunities.

PLM helps Manufacturing operate more effectively. Manufacturing personnel can be involved increasingly in product development and support activities, advising against difficult to manufacture designs, reducing scrap and rework.

PLM helps Engineering Managers develop new products faster, and increase the success rate of new product introduction. It will help them reduce product costs during the development phase, when most of the product costs are defined. It will help them make sure existing designs are reused, or slightly modified, rather than creating new designs from scratch. It will help them control engineering changes and maintain exact product configurations.

PLM helps Product Support Managers develop and implement strategies to better support each product that they're required to maintain.

6.3.2 People Who Make Change Happen

6.3.2.1 Sponsors

Sponsors are the people at the top of the company who provide the backing for change. They provide resources and time for the change activity. Sponsors are usually senior executives who are already fully stretched running the business. Often they don't know exactly what change is needed. But they do know that change is needed. And they're prepared to provide the resources and keep the focus on business objectives. But they don't have the time to develop a change plan and make it happen on a daily basis.

6.3.2.2 The OCM Team Leader

Once it's been decided that the company is going to change, then a change leader will be needed to manage all of the everyday change activities and ensure the project remains on schedule. However, the change leader can't carry out all these detailed change activities. A Change Team will be needed. It will be part of the team carrying out the PLM Initiative. It's the Change team members who will be deeply involved in detailed change activities. The role of the change leader is to lead the drive for change. It's not to get involved with the minor details of every change.

The change leader receives authority and responsibility to make changes happen from top management. As the team's activities are going to be cross-functional, and involve working at many levels of the company, the Team leader should be selected with care, taking account of the typical characteristics for a good change leader (Fig. 6.15).

6.3.2.3 The OCM Team: Change Agents

The Change Team members are Change Agents. These are the people who really make the changes happen.

an ability to work with a wide range of people. The change team will probably include people from many functions and many levels. And people from many levels and functions of the company will need to be involved
good communication skills. The change leader will need to be able to communicate effectively with top management, the change team, and people in all functions that participate in the product lifecycle
a good understanding of why change is necessary
sufficient resources (people, money, time) to make change happen. Many change leaders will fail because the necessary resources aren't available
able to take and tolerate risk. Almost by definition, change projects involve a lot of risk
able to delegate. It's not the role of change leaders to carry out all the changes, but to make sure the changes occur. It may be difficult for leaders, who have been hands-on, to find a balance between leadership and details
able to listen to what other people are saying. Change won't occur if the change leader only tells other people what to do. The change leader has to be able to stop talking and start listening
good sales skills. The change leader will have to sell the need for analysis and change to some cynical, worried, inflexible and apathetic functional managers, and to sell the results of the analysis to a wide variety of people
be an able and willing coach. Many people will have little idea of the entire scope of the change project. They'll look to the change leader for guidance
be a good builder of team effectiveness. The change leader must bring the right people together and get them to work together as an effective team
be able to keep track of progress. Many things will be happening simultaneously in a change project. The change leader needs to have them all under control
be interested in the company and in change. The change leader should be deeply interested in finding out how things work today, and how they could work better in the future
have a good knowledge of the product development and support activities of the company. Practical experience of the way the company works will make the job much easier for the change leader
be credible. The change leader needs a sufficiently wide range of experience, and an action-oriented and relatively unblemished reputation in the company
be optimistic, able to inspire, and success-oriented. At times, a change project will seem never-ending and likely to fail. At such times, the change leader must find the will to keep moving forward, and to motivate the team
able to behave in the project as if change has already occurred. If people see their change leaders haven't changed their own behaviour, they aren't going to believe that they can change anyone else's behaviour
be able to stay with the change project. The change leader should stay with the change project from beginning to end. Changing change leaders in mid-project is even more risky than changing horses in mid-stream

Fig. 6.15 Typical characteristics of a good change leader

The Change Team may include external resources with good Organisational Change experience and skills. The Change Team members who work for the company also need to know the techniques of Organisational Change Management. Change Team members should be knowledgeable about the company and its products. They should be respected within their company. They should be assigned enough time to participate in the project. They need to understand how products are managed today, understand the future target, and understand the required changes. Other characteristics include involvement, commitment, being supportive, hard-working, open-minded, having the power to make changes happen, and a good understanding of the fact that nobody knows everything.

The detailed tasks that change agents will carry out will be different in different companies and in change projects of different sizes. For example, they may develop detailed project plans and oversee their implementation. They may look for ways to identify and remove barriers to success. They may ensure on-going communication about the change. They may work with the Finance organisation to identify the bottom line impact of the change.

6.3.2.4 Champions

Champions are very visible and active supporters of change. Change Leaders and Change agents may be champions. Sponsors are less frequently champions.

6.3.3 People in the Product Lifecycle

Many people from across the lifecycle will be involved in the PLM Initiative. Many will be expected to change. Their willingness to be involved and to change may depend on parameters such as their hierarchical level or their functional speciality. The following sections give an overview of how some of them may react to the Initiative.

6.3.3.1 Functional Managers

Managers running a functional department, such as Marketing, Engineering or Manufacturing, live in the real world, and are expected to produce instant results. As a result, they may not show much interest in benefits of PLM that may appear in two or 3 years' time. By that time, perhaps, they'll have moved on to another position or company. They're often so busy working at day-to-day problems, that they can't get involved in long-term issues. Their primary concern is to meet the short-term targets set for them by the CEO.

6.3.3.2 Marketing Managers

Marketing managers will react positively to PLM. They'll find subjects of interest for their future. PLM will provide them a new reason to identify more finely segmented niche markets and imagine corresponding products. Marketing can claim to be listening to the voice of the customer and customising the product line. At the same time, they'll grumble about the time it takes engineers to develop the new products, and the inability of the sales force to actually sell the products. PLM can help Marketing Managers make sure better and faster responses are made to Requests For Proposals, material from successful proposals is re-used, and proposals are priced realistically and competitively. It can help get better feedback about product use.

However, Marketing is already stretched by the CEO's demands for faster, deeper and wider market penetration. So it's unlikely that Marketing managers will offer resources to work on the PLM initiative.

6.3.3.3 Manufacturing Managers

Manufacturing managers will react positively to PLM. But they'll claim they've been set the objectives of reducing costs, improving productivity and maintaining Six Sigma quality levels, and they can't see how these targets can be achieved by PLM. After all, they'll say, PLM should be the responsibility of the design engineers who create the products. In private, of course, the Manufacturing managers will agree that anything that gives some control over design engineers and product data must be a good thing. PLM can help Manufacturing operate more effectively. Manufacturing personnel can be involved increasingly upstream in product development activities, advising against difficult to manufacture designs, reducing scrap and rework.

However, the Manufacturing organisation is already working flat out to meet the CEO's demands for increased product diversity yet higher production rates. As a result, it's unlikely that Manufacturing managers will offer resources to work on the PLM initiative.

6.3.3.4 Engineering Managers

Engineering managers know only too well how difficult it is to develop new products in response to constantly changing requirements. They're used to constant changes from Marketing and Manufacturing, and try to improve their responsiveness. Only too often though, they find that in spite of all their efforts, they finish up with the same results of late delivery and poor quality. They know that sometimes they aren't in complete control of the projects entrusted to them. But there are so many unforeseeable external influences. However, as they look around, they see the potential for improving the situation. They see time wasted as drawings are manually transported from one activity to another. They see time wasted as information waits to be signed-off. They see their engineers going into far too much detail where it's not needed, and not enough detail where it's needed. They see an unnecessarily high number of signatures holding progress back. They see Marketing personnel wasting their time going far too deep into technical details. They see Manufacturing personnel doing nothing as they wait for information. They see support engineers wasting time trying to use technical manuals that are out-of-date. They're aware of the scrap, the personnel time that's wasted, the possibilities of reducing the product development and support cycles. They know that late market entry is going to cost the company a lot of money. They understand as well as everyone else that the time to reduce product costs is during the development phase, when most of the product costs are defined. They understand that it's much cheaper to reuse, or slightly modify, an existing design than to start a new design from scratch. Like everyone else, they know that it's important that engineering changes are controlled and that exact product configurations are maintained. Unlike everyone else though, they're responsible for getting these things done, and in practice they know it's not as easy as it looks. As a result, most Engineering managers will welcome PLM.

However, all Engineering resources will be booked on high priority projects to get new products to market quickly. And the Engineering budget will have been spent on new applications. As a result, it's unlikely that Engineering managers will offer resources to work on the PLM initiative.

6.3.3.5 Product Support Managers

Product support managers are at the end of the Marketing-Design-Manufacturing-Sales-Support chain in a company. They're faced with many problems generated earlier in the product lifecycle. For example, people in Field Service often have no way of knowing what's been configured in a particular product that they're required to service. Design engineers might send them an "as-designed" configuration, but all sorts of things can have changed since that was produced. Design Engineering may change components but not tell anyone. Some of the sub-assemblies may be purchased, and have different components compared to the initial in-house design. Manufacturing might also make changes. At the Assembly and Test stages, where there's always a lot of pressure to get the product out the door, additional changes may be made but not get properly documented. Another example is that when the Installation teams of, for example, machinery makers, go out to the installation site, they often find that a lot of the parts are missing or don't fit. Between the Marketing, Engineering, Manufacturing and Logistics Departments of the numerous organisations in the supply chain, there may be all sorts of misunderstandings, and the end result is that installation isn't completed on time. Most product support managers will welcome PLM, and will provide valuable input to the PLM Initiative.

However, everybody in the Service organisation is already working overtime to provide essential support to customers. So it's unlikely that Product Support Managers will offer resources to work on the PLM initiative.

6.3.3.6 PLM Managers

For most PLM Managers, the focus is to manage everyday operations successfully. Often this isn't as easy as it looks. In many cases, there will have been implementation problems in the past, and these are frequently carried forward rather than solved. However, the budget for them has usually been spent in the past. These legacy problems can be particularly difficult to solve without a budget. They complicate both the management of everyday PLM operations and the planning of future PLM operations.

Most PLM Managers would like to have more financial and human resources so that they can make faster progress with their PLM implementations. However, they're often faced with pressures to reduce costs and headcount. Business executives in their companies often assume that, if the current implementation is running, it could run just as well with slightly reduced resources.

Everybody in the PLM organisation is already working overtime to maintain current levels of support. So it's unlikely the PLM Manager will offer resources to work on the PLM initiative.

6.3.3.7 Product Engineers

The product engineers hear a mixture of messages. Managers keep telling them to be closer to customers, and develop more and better products and services faster. Instinctively, they feel that would take more time and money, but they're told to reduce costs, improve quality and reduce lead times. At the same time, they're expected to fill in all the forms, and to meet the product development target dates in the company plan. As the individual requirements of the different requests are often different, or even contradictory, product engineers have to walk a fine tightrope. They focus on what they think is most important, and most likely to be used by management to measure their performance. They look for ways to play down the other issues, or to pass them on to others. Probably there will be one or two key products that must be produced on-time and to specification. Most of the effort will go on these. For other products, Marketing and customers will be blamed for not providing full specifications, and for continually changing the specifications. Manufacturing will be blamed for not being able to produce the products that have been defined. If all else fails, the target of reducing lead times can be achieved by releasing unfinished work to Manufacturing. Of course, this will come back later in the form of rework, but since no-one will have set a target for reduction of engineering changes, hopefully this will go unnoticed by management. Sometimes, Manufacturing will also be under pressure, and won't have time to fix the problems.

Then the customers will complain about the problems. That will mean more work for the support engineers. Of course, they'll complain loudly, but actually they'll be happy to be paid overtime for the extra work.

Product Engineers, with all sorts of daily problems to worry about, may not be very interested in whether or not PLM is introduced. They may understand the benefits it can bring, but doubt that it will ever work as proposed, help them in their daily work, or be implemented before they retire. They may prefer not to get involved with an Initiative that may fail and give participants a bad name. And overloaded with daily problems, it's unlikely that they'll have time to work on the PLM Initiative.

6.3.3.8 Service Providers

In addition to the company's employees, people from customers and suppliers are also potential participants in the PLM Initiative. A customer told me about the proposals he'd received from service providers wanting to help him (Fig. 6.16).

6.3.3.9 Accepters, Blockers, Sleepers

Change Leaders, sponsors, agents and champions all try to make change happen. There are never many of them in an organisation. The number of people who are really going to make change happen is rarely more than a few percent of the people in the organisation. Change happens to the great majority of the organisation. Some of them, the accepters, will accept change and do their best to make it succeed. Some, the blockers, will try to prevent change. Others, the sleepers, will neither support nor prevent change.

6.3.4 Roles

Roles have to be defined clearly both for the change project and for the environment after the change has occurred.

Service Provider	*Proposal*
a management consultant	told him he should focus on processes rather than information management
a system integrator	offered to develop the interfaces to get all the applications working together
a product development expert	suggested that engineers should be taught to develop better product specifications
a business process consultant	told him that he should define the product lifecycle processes in detail
a professional trainer	told him the future is ERP, and proposed training on use of an ERP application
a strategy consultant	told him that he should start by identifying the required management skills
a professor	proposed a project to development rules that engineers should follow
a consultant	told him that the first thing to do was to cleanse the product data
a human resources expert	suggested role-playing games to prepare his people for the PLM environment
a management consultant	told him he should focus on information management rather than processes

Fig. 6.16 Proposals from service providers

6.3.4.1 Role in Change

Some roles may exist both during the change and after the change has occurred. An example is the Functional Power User Role for a new approach to New Product Development (NPD). This role has a wide range of responsibilities (Fig. 6.17).

Ideally, the Power User for a particular function will be someone from that function who has recently been actively involved in the existing approach to New Product Development, and is expected to continue to be involved in future NPD projects.

Attributes for this role include: good knowledge of the roles of their function; cross-functional experience and understanding; extrovert with the ability to influence and motivate peers and superiors; good project management skills; a can-do attitude; eager to lead change and drive the improved way of working.

6.3.4.2 Roles of Lifecycle Participants

The roles of participants across the product lifecycle need to be clearly defined, documented and communicated. Documenting them shows exactly what is required, and reduces the possibility for misunderstanding. An example is given for the Product Development Engineer role.

The Product Development Engineer (PDE) will be responsible for the technical support of products and solutions which are already on the market.

The PDE will lead, or participate in, trouble-shooting activities to improve or modify products, in collaboration with a multidisciplinary team including people from marketing, service, manufacturing engineering, test, quality, purchasing and disposal.

The PDE will think about products across their lifecycles, taking account of how they fit in their product family and how they will be manufactured, disassembled and recycled. The PDE will know what platforms and parts exist, and how to re-use existing parts in improved products.

The PDE will understand the complete product lifecycle, and they'll know the roles and responsibilities in the business processes. They'll be familiar with the company's product development and support methodologies, as well as development guidelines and procedures. They'll understand their role in the business processes across the product lifecycle, and the related tasks and product data.

understand the new ways of working	report experience to the NPD Project Team
understand new roles	be the single point of contact for their community
prepare their functional community for change	provide on-going support to people in their function
drive roll-out of the new approach in their community	collect feedback from their community
be a test user of the new approach	share feedback with the NPD Project Team
identify training participants within their community	collect NPD improvement suggestions
train people in their community	nominate community members for recognition
share NPD best practices with their community	on-board new members of the community
work in projects according to the new approach	refer issues to the Process Owner

Fig. 6.17 Responsibilities of the Functional Power User

The PDE will know where the product data that they use comes from. They'll know who uses the product data they produce. They'll know why it's needed, and how it has to be prepared, structured and stored.

The PDE will work with the company's CAD/CAE, test and PDM applications according to the company's guidelines.

The PDE will need soft skills, such as the ability to work in a team, and the ability to communicate well with colleagues. They'll need to be able to work with people who come from other functional, cultural and national backgrounds. They'll need to be adaptable and a fast learner, open to new ways of working, new ideas and new challenges. If the PDE sees weaknesses and potential improvements, they're expected to communicate them to the appropriate people.

6.4 Reality in a Typical Company

6.4.1 Generic Issues with Change

In a typical company, there will usually be many issues with Organisational Change in the PLM environment (Fig. 6.18).

There will usually also be many issues with the change activities that make up the OCM sub-project of the PLM Initiative (Fig. 6.19).

6.4.2 OCM Interaction with Company Resources and Initiatives

The OCM sub-project of the PLM Initiative isn't an island isolated from the rest of the Initiative and the rest of the company. Every Organisational Change proposed in

the required change isn't clearly defined	the required change isn't clearly communicated
the required change isn't clearly documented	ownership of the change isn't clear
the reason for the required change isn't clear	multiple versions of the same change
the objective of the required change isn't clear	no "change process for managing change"

Fig. 6.18 Generic issues with Organisational Change

key people leave project at short notice	changes are interlinked
not enough time to communicate	not enough training
change activities that don't add value	too much detail, or not enough detail
lack of visibility on the activities	people don't understand the language
slow performance reporting	people don't understand the tools
targets of change unclear	training is given at the wrong time
no agreement about change activities	unclear responsibilities
no process for OCM	unknown status of change project progress

Fig. 6.19 Generic issues with Organisational Change activities

the Initiative will be related to at least one of the components of the PLM Grid (Fig. 1.5). In addition to the PLM Initiative, most companies will also have several other initiatives running. Company Initiatives address many different subjects, but their objective is always to improve performance, in other words, to change. These Initiatives may also have OCM sub-projects, and there may be overlap with the OCM sub-project of the PLM Initiative. To avoid problems, it's important to identify the other company initiatives and find out if and how they may interact with the PLM Initiative. And then work out how to harmonise change activities.

6.5 OCM Activities in the PLM Initiative

A PLM Initiative takes a company from its current PLM situation to a desired future PLM situation (Fig. 3.32). We've never seen a PLM Initiative that wouldn't benefit from OCM.

6.5.1 Projects Related to OCM

In most PLM Initiatives, there are many activities addressing change (Fig. 6.20) Depending on the Initiative, some of these may run independently. Some may run in parallel, or overlap. Many will be linked to other projects in the PLM Initiative.

It's likely that many of the people in the PLM Initiative will know little about OCM. Coming from different backgrounds they may have very different understandings of OCM. So it's helpful to develop a glossary that gives short definitions of the various terms and techniques used in OCM. This should lead to a common understanding of the subjects to be addressed.

Similarly, some of the people in the OCM Team may know little about OCM. Many of the team members may never have participated in change activities. It may be difficult for them to know how best to plan their activities and go about their work. As a result, some training about organisational change and Organisational Change Management will be useful.

prepare training for the new situation	align expectations of change	create the training plan
provide training for the new situation	plan tests for new processes	recognise achievements
support individuals in new situations	clarify new responsibilities	plan roll-out activities
provide awareness training about OCM	clarify new job descriptions	create roll-out strategy
clarify the OCM approach and steps	develop new reward systems	plan OCM activities
develop new means of recognition	communicate about changes	prepare new roles
plan tests for new applications	help restructuring activities	mentor
create the communication plan	develop an OCM Glossary	coach

Fig. 6.20 Examples of activities related to Organisational Change

6.5.2 Plan the Change Project

To launch an OCM project, we take a ten-step approach (Fig. 6.21). We've developed it based on experience gained in projects calling for extensive Organisational Change.

In Step 5, it's important to clarify the characteristics of the required changes (Fig. 6.22). If we can't clarify a change, we question whether it's really needed.

In Step 6, the OCM Team that is created needs to have the right people, with the right mix of skills and levels. It needs to be correctly positioned in the PLM environment. There could also be a Steering Committee, stakeholders, a sponsor, the PLM Core Team, extended teams and SMEs.

In Step 7, it's important to clarify the characteristics of the expected change activities (Fig. 6.23). Again, if the characteristics of a proposed change activity aren't clear, we question whether it's really needed.

There will usually be some changes needed to the initial high-level OCM Plan, but that's why it's a draft. It's there as a starting point that will be detailed as everyone finds out more about the project. And it will continue as a rolling plan.

6.5.2.1 Success Factors for OCM

OCM projects are likely to be challenging. They're likely to upset some people. It's useful to know some success factors for OCM projects (Fig. 6.24).

1	Identify the Sponsor. Ensure top management involvement and support
2	Select the OCM Team leader
3	Understand the targeted situation. Clarify the objectives. Ensure objectives are realistic
4	Understand the current situation
5	Understand and document the required changes. Clarify their targets, achievement criteria, affected people
6	Create the OCM Team. Position it in the PLM environment. Define OCM Team roles and responsibilities
7	Identify likely tasks related to expected change activities such as training, coaching, mentoring, communication, changing reward systems, planning roll-out, testing, monitoring performance and benefit achievement, reporting, ...
8	Identify tasks to reinforce change and to ensure on-going change
9	Identify easy-to-achieve short-term wins
10	Create an initial draft high-level OCM Plan

Fig. 6.21 Ten step approach to the OCM plan

scope	motivator	reason	benefits	value
definition	need	size	owner	target

Fig. 6.22 Characteristics of a change

methodology	approach	strategy	KPIs
sequence	roles	responsibilities	leader

Fig. 6.23 Characteristics of a change activity

understand the change methodology	define and design changes carefully
clarify the need for change and the expected changes	target some short-term wins
recognise the need for a professionally run OCM project	reward success, celebrate achievements
select and support change leaders	maintain the focus on change and on people
create and maintain a need for urgency	sustain achieved changes, continuously improve
develop and communicate a Change Vision	provide training
develop strategies and plans to achieve the vision	keep track of successes
remove obstacles to change, allow risk-taking and new ideas	define and design changes carefully
define as-is, intermediate and to-be states	get stakeholders on board

Fig. 6.24 Success factors for organisational change

6.5.3 Communication

Communication is important to overcome the fears and concerns aroused by change. People wonder what effect the change will have on them. Will they still have a job after the change? Will they maintain their rank? Will they have an interesting role? What will their future be? Because these questions will always be asked, and uncertainty in a working environment reduces productivity, it's important to communicate what's changing and why.

Communication is an on-going process. It's clearly necessary to communicate to people at the beginning of a change project. It's important to answer their initial fears and concerns. It's also necessary to communicate throughout the intermediate states of the change process. As the change process advances, two things happen. People will have new questions to be answered, and new ideas and understandings of the intermediate and final states will be developed. In response, people have to be kept up-to-date with actual and future states. And answers have to be given to their questions.

There are four key subjects of communication (Fig. 6.25). People need to be informed of the reasons why the organisation has to move away from the current as-is state, and of the dangers of staying there. They need to understand the pressures that make it necessary to change. It has to be explained to them that the current state used to make sense, but because the environment in which the organisation exists is changing, the organisation must also change. It has to be explained what will happen if the organisation doesn't change. And what this will mean for them as individuals.

It's also important to communicate the future state, the PLM Vision. What will it look like? Why will it look like this? What are the advantages of being in this state?

the present state	the intermediate states	the future state	the change activities

Fig. 6.25 Four key subjects of communication

Which parts of it are clear? Which are still hazy? What will this future state imply for the roles of people in the company?

The intermediate states of the organisation are unsettling for everybody. In these states, it's no longer possible to cling to the familiar past. And the hoped-for future state feels as if it's never going to be reached. Communication about the intermediate state gives people the confidence that though they may appear to be in a state that's completely out of control, this state has been recognised in the planning process. They'll see it was foreseen as a necessary step on the path to the future state, and that before long it will be over, and the organisation will have moved into the future state. The communication needs to show them how the future state will be reached, and what things will look like along the way.

The activities of the change process have to be communicated. Inform people about the reasons for change and the benefits of change. Tell people what's going to happen, when it will happen, and why. Tell them who will be involved. Get them to understand that the process has been clearly thought-out, is well-led and well-planned, and is under control. Show how the process will help people to participate in the change and how it will help them to change. It's important to communicate these messages. Otherwise nobody will know what's happening. Nothing is obvious, and telepathy doesn't exist.

Communication can be carried out in a variety of ways such as a Newsletter, e-mail, blog, twittering, video, person-to-person, or in small groups. Person-to-person communication takes a lot of time and doesn't provide the synergistic benefits of presenting the message to a group of people. A Newsletter can be a good communication tool but there's always the danger that some people, overloaded with everyday work, will be "too busy" to read it. Videos tend to over-formalise communication, and don't provide a direct way for people to ask questions. E-mail suffers from being a generally inaccurate communication medium that's easy to ignore and delete.

The best method of communication is for each manager to communicate a well-prepared change message and accompanying support material to their direct reports. This process should start at the top of the organisation and be followed at each level. As a result, most people will first hear the change message from their boss and be able to ask questions. And then they'll be forced to understand the message well enough so they can communicate it to their team members, and answer their questions. In this way, a single message and accompanying support material can be communicated throughout the organisation.

Most people in the organisation will have a lot of questions about the change process. For any one of a variety of reasons, they may not like to ask these questions directly to their boss or colleagues. It's always best to include some mechanism in the communication process by which people can ask questions anonymously, or off the record. And finally, don't forget to put a feedback process in place to make sure that the communication process is meeting its objectives.

6.5.3.1 Communicating a Simple High-Level PLM Message

Whatever the details of the PLM Initiative, it's always good to be able to communicate a simple high-level message. One company we worked with called its initiative CHAIFA (Commonise, Harmonise, Align, Integrate, Fill, Add). This communicated the six main elements of the strategy and their relative priority. Achieving a common approach across the company, wherever possible, had the highest priority. CHAIFA was the concise high-level message. At lower levels there was a mass of detail about projects addressing many PLM components at many sites. Another company focused on four main elements in its message (Fig. 6.26).

Activities addressing the focus on value included partnering with risk-sharing assembly providers, and outsourcing or off-shoring of low-value activities. Unification activities included integrating independent national company organisations, and integrating unconnected applications. An example of harmonisation was to implement the same version of a CAD application on all sites. Alignment included adjusting workflows in an application so that they were in line with the steps defined in the corresponding business process.

6.5.3.2 Communicating the PLM Vision

People in the company need to know the PLM target towards which everyone should work. This target is usually expressed in the PLM Vision, a high-level conceptual description of a company's product lifecycle activities at some future time, usually 5 years in the future.

A PLM Vision represents the best possible forecast of the desired future situation and activities. It outlines the framework and major characteristics of the future activities. It communicates the fundamental "what's, why's and where's" of PLM. It provides a Big Picture to guide people in the choices they have to make, when strategising and planning, about resources, priorities, capabilities, budgets, and the scope of activities. There's a saying, "a ship without a destination doesn't make good speed". Without a PLM Vision, people won't know what they should be working towards, so won't work effectively.

A PLM Vision for the company will enable all PLM participants and decision-makers to have a clear, shared understanding of the objectives, scope and components of PLM. A PLM Vision is a focal point for everybody in the company that says: "this is where we're going". The Vision is a useful basis for communication about PLM between all those involved with PLM, such as executives, IS managers, Product Managers, product developers, service staff, recycling managers and other stakeholders. It allows everybody to "work from the same book" and "sing from the same page".

Value	Harmonisation	Unification	Alignment

Fig. 6.26 Four key deployment elements

Communicating the Vision gives many people an overview of what PLM is, and what it will be, why it's important, and how it will be achieved. The Vision has to be communicated to everybody likely to be involved in the future product lifecycle activities or impacted by them.

6.5.4 Learning and Training

Learning is important because, at the beginning of the change process, people don't know anything about the targeted to-be state, or how they're going to work in it. So they need to learn. They may have done a good job in the past, but that job is going to change in the future and, without learning, how will they be able to do their new job?

Companies have to change if they want to survive in a changing competitive environment. When a company decides to change, the people who make up the company also have to change. People have to learn about the way the company wants to work and how they're expected to work. They have to learn the skills, behaviour, culture and tools that will enable them to work in the expected way. Many companies have understood the importance of learning as a foundation stone for building change, and there are many related terms such as the learning organisation, the learning factory, and continuous learning.

The content of the learning depends to a certain extent on the needs of individual job functions. There are things that design engineers and recycling operatives need to learn about that will be of no use to, for example, top managers. Similarly, there are things that project managers need to learn about that aren't needed by design engineers.

One part of learning can be considered as education or theory, and the other part as training or practice. Everybody needs to get a common overview of the changes. This overview is educational. It's usually provided in the form of a seminar or presentation. It may be possible to customise the seminar to particular groups of people so that it addresses some of the specific issues they'll be faced with. But usually it's not possible, in a general seminar, to get down to the level of the individual. That has to be addressed in small groups, or in one-to-one training.

It's often difficult to decide exactly when learning should take place. There's usually a tendency for it to occur too early. This is simply because if it's left too late, people won't be able to do their jobs effectively. However, it's just as dangerous for learning to take place too early, as it is for it to take place too late. Educational overviews that are given too early can be forgotten before their content becomes relevant. Training is ineffective if it can't be put into practice. And, when training takes place too early, people often get trained in the wrong order. It's always best to train people after their supervisor or manager has been trained and, if possible, get them trained by their supervisor or manager.

One of the first tasks in putting together the learning program is to work out who will follow the program and what kinds of grouping can be established. In a big company, the change program may affect thousands of people, so there'll be lots of possible ways to group people. Probably there'll be a top management group. And then groups built on a departmental, functional, product, project or geographical basis. At the next level down from top management, there may again be a top-level group, then a group of project managers, then groups of engineers. The choice of grouping should reflect the structure of the future organisation. This will help people to see how the new structure is going to work.

The first steps towards implementing PLM are to understand what it's about, its objectives, its scope, and the steps towards successful PLM.

It's best to get some outside help with the preparation of the education and training. There's a real danger that if people who lived in the old environment prepare the program they won't be able to shake off all their old habits and culture. As a result, the trainees will see the same people, and hear the same old messages coming through. They'll think "Oh no, not this again. These guys aren't serious about wanting change if this is how they're doing it. They can't even change themselves." A new broom sweeps clean. An old broom leaves behind the same dirt and fluff.

It may seem that everyone in the organisation will want to learn as quickly as possible about the new environment and their new role. But human nature isn't like that. Many people will have a different attitude. Why should I make an effort to learn something new? This is a lousy presentation. If these guys can't come up with something better, I guess it means that it's not important.

To avoid this kind of negative response, the learning activity must be organised as an important project in itself. There should be a training plan for the whole learning activity. It should outline what needs to be done, and when it should be done. Find out what people know, and what they need to know. Work out what they need to learn. Make sure the components of the plan fit together properly. Make sure that, as individuals go through the learning program, they are building on previous learning. And don't forget to include feedback sessions in the plan to make sure that learning really is occurring.

The initial understanding and awareness of PLM shouldn't be restricted to the Team, but spread as widely as possible. Management should be kept up-to-date, as should potential PLM users. The more that management knows about PLM, the more supportive it will be of the Team. The more that the users know about Team progress, the more supportive they'll be, and the less likely they'll be to start independent competing activities and overlapping projects.

6.5.4.1 Coaching and Mentoring

Mentoring, typically of executives and middle managers, supports and encourages their development in the PLM domain. Coaching, typically of individual PLM Initiative team members, helps them to develop specific skills and knowledge in areas such as analysis, planning and strategy development.

6.5.5 The Reward System

Communication and learning are important. But the problem is that, even if the change message is well-communicated and well-received, and people are given the opportunity to learn so they can behave differently in the new environment, it doesn't follow that anyone is going to change their behaviour. First, they'll look to see on what basis the congratulations and the complaints are going to be distributed. If they see that the rewards and punishments are going to be handed out the way they always were, then they're going to behave the way they always did. They're not going to change.

Communication and learning systems can seem theoretical. Of course it may cost something to produce a communication package, and to put the learning system in place, but these activities don't actually hurt anyone. It's only when the change process begins to change the reward system, that people are going to be in danger of getting hurt, and everyone will be able to see if management is really serious about implementing change.

Why's this question of the reward system so important? Because people only work for the reward. For some people the reward may be mainly financial, but for others it will be a question of good company, good coffee, status, brain stimulation, good resorts and restaurants, and free tickets for Buckeye games.

Before the change, people were enjoying their rewards and having a good life because they were rewarded for working the way they were expected to work in the past. Now they're asked to work differently and to behave differently. So they'll have to be rewarded differently. First, they'll need to be rewarded for changing, and then they'll have to be rewarded for working the way they're expected to work in the future. They'll be rewarded twice for changing. Once for getting the right skills and once for behaving the right way.

They may be asking themselves many questions. "If I've got to work to get new skills, what's in it for me? How's it going to work in the future if I'm doing a great job in a team, but the other team members aren't? Why should I lose out because the others aren't performing? And my future? How am I going to move up the tree if there are fewer branches? Just what sort of reward will I get in the future? Is it worth the effort to change?"

Before plunging ahead with a change project, questions need to be asked, and answered, about the current and future reward systems. First, concerning the current system. What are the current rewards? What's currently rewarded? How are the rewards given? And then about the future system. What should be rewarded? What are the rewards going to be? What's the scoring system going to be? Who's going to be doing the scoring? How will rewards be given? Who's going to be rewarded? Who will do the rewarding? Everyone needs to be informed of the answers to these questions up-front.

It should be made clear to the people who do the rewarding that if they don't give a reward that's due, they'll be in deep trouble. They'll be giving the impression that the company isn't serious about change. And once people start thinking that the company isn't serious about change, and begin to doubt the rewarder's integrity, then no-one's going to change their behaviour.

The late Judge Tuttle said, "the professional man's only asset is himself. If he does not contain the quality of integrity he is worthless. If he does he is priceless." Good change sponsors must have the quality of integrity, and are priceless.

6.6 Learning from Experience

Organisational Change should be addressed in all PLM Initiatives. From experience with many companies, lessons can be learned about the best, and worst, ways to proceed.

6.6.1 Tips from the Trenches

6.6.1.1 Getting Started

My first consulting activity related to training was with a major computer manufacturer. They were known for the many weeks of training they gave their employees each year. Fortunately, for my first experience of training development, I was just a Subject Matter Expert, and my colleague was a very experienced trainer. Before we made the proposal, he asked me how many man-days we would need to propose for the development of 1 day of training. I replied four. He told me it was fifteen. He said he was a professional trainer and his reputation was on the line. He had to run a training program that would help people acquire new skills. At the end, they would be tested to see if they had acquired the skills. If they hadn't, we would have failed. And his reputation would suffer. It turned out he was right about the 15 days. We produced a great training session, and were asked to come back.

6.6.1.2 Repeat Performance

Something similar happened with a company in the transportation sector. The Human Resources person asked me how many man-days I would need to develop 1 day of training about a new process. I dutifully replied fifteen. I was asked to develop a training program. Based on my previous experience, I knew what was needed. The HR person liked the program and it was used to train everyone involved in the process.

6.6.1.3 Luxury Goods Manufacturer

We often find that people in a PLM Initiative don't know what's needed for training. Usually we get asked to participate near the beginning of a PLM Initiative, so we were surprised when a luxury goods manufacturer asked for help several years into their Initiative. They were nearing the end of the Initiative, and their consultants had delivered the final training session. The problem was that the company's managers and users claimed to have understood nothing. The company wouldn't show us the training material that the consultant had used, so we had to start from scratch. We developed the training session and ran a dry run. Everybody was happy, so we went on and trained everybody. As usual, people spilled the beans, and we found out that the consultants' "training program" was a set of high-level marketing slides about PLM unrelated to everyday work.

6.6.1.4 Consumer Goods Manufacturer

The story was similar in the PLM Initiative of a consumer goods maker. The main difference was that the service provider's idea of PLM training was to put people in front of the software for a day and tell them, click here, click there.

6.6.1.5 You Can Take a Horse to Water

In one assignment, we assisted a machine manufacturer with a PLM Initiative that included harmonisation of business processes and implementation of a PDM system. The Initiative ran for a couple of years. The VP asked us how much training we thought was necessary. We replied that one or two days would be good, and that about fifteen man-days were needed to develop 1 day of training. He said that was much too much, as everyone was overloaded finishing off projects to get new products to market before the end of the year. Instead, he said we'd limit it to 2 h, and he'd show them the slides he'd used to introduce the project at the Board Meeting. When he gave "the training", the users said they didn't understand how they were supposed to work in PLM.

6.6.2 Be Realistic

6.6.2.1 Are We Able to Change?

Before embarking on PLM, companies should look back over their recent history to understand to what extent they've been able to change in the past. Is there any reason to believe their future behaviour will differ from past behaviour? If everyone behaved the same way in the next 12 months as they had over the last 12 months,

know the targeted outcome of change	understand that change is a major activity in its own right
understand the need for change	find out how to carry out the changes
accept the need for change	carry out change activities
understand the need to change oneself	then implement new application and methods

Fig. 6.27 Steps towards successful change

would PLM succeed? Has top management been heavily involved in changing the operations of the business? Have middle managers demonstrated that they can change?

There are several steps for managers who want to bring about organisational change and achieve successful PLM (Fig. 6.27).

Before going into battle at Agincourt, Shakespeare's Henry V says, "All things are ready, if our minds be so." Are managers sure that the minds of all are ready for the changed environment?

6.6.2.2 Am I Willing to Change?

There's almost a physical barrier to overcome before many people can understand that change won't happen unaided. Gandhi gave good advice, "Be the change you want to see in the world". Yet many people, although they may understand the need for change, don't seem able to respond. Often perhaps, they don't really accept that change for the organisation implies that they personally have to change. It's easy to say that everyone must change, but are you going to change?

6.6.3 Pitfalls of Organisational Change

Organisational Changes occur in nearly all PLM Initiatives. From experience of working with many companies, lessons have been learned. Many potential pitfalls (Fig. 6.28) have been seen. It's good to be aware of them. That will help avoid them.

Approaching, and carrying out, a PLM Initiative without taking account of OCM will lead to the type of results shown in Fig. 6.29.

not knowing the expected target organisation	not having a structured approach
being unaware of OCM	not dealing proactively with resistance to change
starting OCM too late	targeting dollars instead of people
poorly defined change objectives, strategy and plan	not involving employees
poor communication	over-reliance on systems and structure
insufficient support of change agents	lack of change skills and resources
lack of a compelling and urgent case for change	assuming change is complete when first goals are met

Fig. 6.28 Pitfalls of Organisational Change

Result	*Examples and Reasons*
automated bureaucracy	to avoid disputes with their users, maintain all the existing forms. Add a few more forms to enable new activities
perpetuation of duplicate work	to avoid upsetting existing work patterns, continue to enter the same data many times
increased costs	maintain the cost of legacy applications. Add licence and maintenance costs of new applications. Add customisation costs, and costs of new interfaces
increase in activities that add no value	just to be sure, maintain unnecessary notification by e-mail, to too many people, of events of little relevance
departmental boundaries strengthened	to avoid conflict with department managers, focus on activities specific to a department; don't address inter-departmental collaborative activities
temporary solutions set in stone	automate the quick fixes from the past (instead of fixing the underlying problems)
anarchy maintained	allow everyone to work as they like (don't ask anyone to follow the rules)
chaos maintained	enable innovation by allowing prima donna design engineers to behave as they like (don't implement an innovation process)
PLM implemented in just one department	to avoid rocking the boat, restrict the scope of PLM

Fig. 6.29 Results of ignoring Organisation Change in a PLM Initiative

6.6.4 Top Management Role with OCM

6.6.4.1 Objectives

PLM is a top management issue. Top managers define the objectives of product performance, and the way the related resources are managed. They define the PLM-related business objectives. They should define the objective of Organisational Change.

6.6.4.2 Resources and Skills

Top management is responsible for providing the appropriate resources for the OCM activity. Management needs to put in place the right people to work on Organisational Change Management. Once the objectives of the Initiative have been defined, and the scope and size of the changes are clear, they should select the OCM Team leader.

6.6.4.3 Leadership

Top management participation in OCM is needed to ensure that Organisational Change issues are taken into account in the PLM Initiative. Due to the enterprise-wide scope of PLM, leadership has to come from the C-level.

6.6.4.4 Communication

Communication is a key issue in a change project. Top management should ensure good communication of the needs and reasons for change.

6.6.4.5 Support

Top management should strongly support the change project. If top management isn't seen to support the change project, it's unlikely that the project will be supported by the rest of the company.

6.6.4.6 Convince Middle Managers

Top management should convince middle managers of the need for change. Without the support of middle managers, the change project is unlikely to succeed.

Chapter 7
Project/Program Management in the PLM Environment

7.1 Skills and Relevance

7.1.1 Objective

The objective of this chapter is to give a basic introduction to projects and Project Management (PM) as they relate to a company's PLM Initiative. This introduction will help those in the Initiative to understand project-related topics and Project Management activities. In turn, this will help them participate more fully in the PLM Initiative. This chapter also aims to give students a basic understanding of the role and activities of Project Management in a PLM Initiative.

7.1.2 Content

The first part of the chapter is an introduction to projects and Project Management in the PLM environment. It describes the purpose, role and importance of PM in a PLM Initiative. Definitions are given of frequently used terms in the Project Management environment. The need for Project Management is introduced. Project phases, knowledge areas, tools and templates are addressed. Required characteristics of Project Management, including KPIs, are outlined. Frequently occurring roles in PLM projects are described.

The second part of the chapter addresses Project Management in the PLM environment of a typical company. It describes the typical issues with projects and project plans that are encountered in many companies. The interaction of Project Management with the resources of PLM and with other company initiatives is outlined.

The third part of the chapter introduces typical PM-related activities in the PLM Initiative. Benefits and success factors are described.

The fourth and final part of the chapter builds on experience of working with PM activities with many companies. It shares lessons learned from experience of Project

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Management in PLM Initiatives. The potential pitfalls of Project Management are described. Top management's role with Project Management in the PLM Initiative is addressed.

7.1.2.1 Skills

This chapter will give students, who've been assigned this book, a basic understanding of projects and Project Management in a PLM Initiative. They'll learn why it's important. They'll be able to explain, communicate and discuss about projects, Project Management and related activities in a PLM Initiative. And they'll be aware of some companies' experience with Project Management in their PLM Initiatives.

For more information about Project Management, students should refer to *A Guide to the Project Management Body of Knowledge* (Project Management Institute, 2013. ISBN 978-1935589679).

7.1.3 Relevance

Several Project Managers were surprised when I told them that I was including a chapter about Project Management in a book about PLM. They said it was unnecessary. They told me that if someone in a PLM Initiative wanted to know about Project Management they should read one of the many books that have been written about Project Management.

I replied that, having worked in dozens of PLM projects, I had never met anyone, apart from Project Management professionals, who had read a book about Project Management. And yet, in most PLM Initiative there are many projects, and their management is challenging. So, in my opinion, everyone in a PLM Initiative needs to know the basics of Project Management as it relates to a PLM Initiative. A PLM Initiative is made up of many projects, many of which will run in parallel. Each of these may be complex, involving many people, decisions, roles, costs and dependencies. Project Management is really important in such an environment. Everybody in the PLM Initiative needs a basic understanding of Project Management.

7.2 Definitions and Introduction

7.2.1 Definitions

7.2.1.1 Project

A project is a temporary activity carried out by a company to achieve a specific goal. A project has an intended start date and end date.

A project differs from most activities in a company. Most activities aren't temporary. They are permanent, everyday, routine, and organised to achieve the same goal many times. For example, one of my customers was a company that had a manufacturing plant which produced motors for the transportation industry. Every day, about a dozen motors came off the end of the line. The plant carried out the same tasks every day for several years. The workers in the plant didn't do project work, they did everyday routine work.

7.2.1.2 One-Off Project, Repetitive Project

There are two types of project, the one-off project and the repetitive project. An example of a one-off project is the Manhattan Project which produced the first atomic bombs. Another example of a one-off project is the project, announced in 1961 by President Kennedy, to land a man on the moon.

The other type of project is the repetitive project. For example, companies often have many New Product Development projects running at the same time. Each one is a project in that it is a temporary activity, with the objective of producing a specific product. However, each project contains the same tasks. These tasks are repeated, in different circumstances, in each project.

7.2.1.3 Why Project Management?

In a company's everyday routine operations, such as those of the manufacturing plant mentioned above, roles and responsibilities are clear. They're described in departmental guidelines. People work in a particular department such as Manufacturing. They work the way their functional boss, such as the Manufacturing Plant Manager, or the Manufacturing VP, wants them to work.

In most projects, the situation is different because the project is unique and cross-functional. Because the project is unique it doesn't have pre-defined tasks. And, because it includes people from several functions, it's not clear who should be the boss. To address these issues, Project Management, an approach to management that is specific to projects, is needed.

7.2.1.4 Project Management

Project Management is the business process for managing projects. The objective of Project Management is to achieve the project's goal on-time and within the project budget.

Project Management is made up of activities such as planning, scheduling, organising, allocating, leading and controlling of company resources.

7.2.1.5 Program

Just like a project, a program is a temporary activity carried out by a company to achieve a specific goal.

However, a program is made up of many related projects, some running in parallel, some running in series. All of the projects contribute to achieving the goals of the Program. Each project within the Program may start and end at a different date (Fig. 7.1).

In most PLM Initiatives, there will be many projects and sub-projects. The advantages of grouping projects in a program are usually the same (Fig. 7.2).

However, there are various criteria possible when it comes to deciding which projects to group in a program (Fig. 7.3).

7.2.1.6 Project Schedule, Project Plan

A project schedule is a list of a project's tasks that also shows other information, including intended start and finish dates for each task. Examples of the other information it may show include the name of the person responsible for the task and the resources assigned to the task. There are many reasons for making a project schedule (Fig. 7.4).

	Project 1	*Project 2*	*Project 3*	*Project 4*
Timescale				
Y1Q1	Phase 1			
Y1Q2	Phase 2	Phase 1		
Y1Q3	Phase 3	Phase 2	Phase 1, Phase 2	
Y1Q4	Phase 3	Phase 3	Phase 3, Phase 4	
Y2Q1	Phase 4	Phase 3		
Y2Q2		Phase 4		
Y2Q3				Phase 1, Phase 2
Y2Q4				Phase 3, Phase 4

Fig. 7.1 Projects in a program

more effective use of resources	easier to report all the projects in the program
easier to plan all the projects in the program	decision-making becomes clearer and more effective
easier to manage all the projects in the program	likelihood of success is increased
easier to control progress of the projects in the program	less waste, shorter time frames and lower costs

Fig. 7.2 Advantages of a program

projects belong to the same business initiative
projects impact the same part of the business in the same time-frame
projects relate to the same, or to similar, business objectives
projects have overlapping or identical scope
projects share resources

Fig. 7.3 Possible criteria for grouping projects in a program

show interactions between tasks	clarify use of resources
get a better understanding of the objectives	communicate use of resources
create a basis for monitoring progress	clarify task timelines
reduce uncertainty	understand workloads

Fig. 7.4 Reasons for making a project schedule

documented	complete	understandable	under change control
agreed	detailed	easy to change	measurable

Fig. 7.5 Characteristics of a good project plan

Sometimes there is confusion in projects due to different understandings of the word "plan". The Oxford English Dictionary gives two meanings for a Plan. The first is: "A diagram, table or program indicating the relations of some set of objects or the times, places etc. of some intended proceedings". It then gives an example of use of this meaning in 1807 by J. Nightingale: "A local preacher's plan is a paper properly divided and subdivided into columns and squares on which the names of all preachers are inserted, the respective places of their preaching appointments, and the dates of the month". This is the definition of a plan as a graphical display in which activities and responsibilities are shown. In this meaning, a Project Plan is similar to a Project Schedule. Typically, good Project Plans share a small set of characteristics (Fig. 7.5).

The Oxford English Dictionary gives a second definition of a Plan: "A formulated or organised method according to which something is to be done; a scheme of action, project design; the way in which it is proposed to carry out some proceeding". With this meaning, a Project Plan is the overall approach or method chosen to carry out the project. With this meaning, a Project Plan isn't the same as a Project Schedule, it's not a list of tasks.

7.2.1.7 Project Manager

The Project Manager is responsible for on-time, on-budget achievement of the project's goals.

7.2.1.8 Project Management Office (PMO)

A Project Management Office provides administrative support to the project manager and to other project participants (Fig. 7.6). The role of a PMO varies widely from one project to another. In some projects, the PMO is a key hands-on participant in managing the project. In other projects, the PMO may just have an advisory role. And sometimes a project doesn't have a PMO.

advising about best practices for project management	tracking project execution progress
preparing and maintaining the project schedule	preparing risk and issue analysis
organising training and meetings	tracking costs
providing training about special techniques	preparing project plans

Fig. 7.6 Examples of support provided by a Project Management Office

7.2.1.9 Program Management Office (PMO)

A Program Management Office is similar to a Project Management Office except that, instead of addressing a single project, it addresses the many projects of a program.

7.2.2 Characteristics of Projects

All projects are different, but they usually have a few things in common, a small set of important characteristics (Fig. 7.7). In all projects everything about these characteristics needs to be clear. Anything that isn't clear will lead to hesitation and confusion. Time and money will be wasted.

For example, the purpose of a project, its goal, needs to be clear. If it's not clear, then people will get confused. They won't be sure about what they should do, and they won't work as effectively as possible. Similarly, the scope of a project needs to be clear. Its boundaries should be clear. Otherwise, people may work on out-of scope activities. That will waste time and money. The start date and the end date of the project need to be clear. Otherwise, people may start working at different times and tasks will get out of synch. Similarly, the tasks of a project need to be clear, as do the participants in the project, the roles of the participants, the tools they use, and the owner of the project.

7.2.2.1 Benefits of Project Management

PLM Initiatives have many of the characteristics that typify, in other domains, projects that have a high risk of failure. For example, they have cross-functional aspects, lead to organisational change, and involve changing the way that people work. They can address numerous skeletons in cupboards that haven't been opened for years (such as product structures, classification systems, product development work practices, and interdepartmental interfaces).

goal	purpose	scope	tasks	tools	costs	budget	name	owner
governance	schedule	dates	roles	participants	customer	KPIs	plan	manager

Fig. 7.7 Project characteristics

best way to achieve the expected results	effective teamwork
enables use of common templates	more predictable results
reduces cost and time overrun	better management of risks
over time, identification of best practices	leads to faster delivery

Fig. 7.8 Features of project management

Project Management offers features to help overcome any issues resulting from such characteristics and achieve a successful PLM Initiative (Fig. 7.8).

7.2.3 People in Projects

There are projects of many different sizes, ranging from very small to gigantic. Projects of different sizes have different needs for people and for the way that people are organised. In a very small project, there might be just be a sponsor and a project manager. However, for large projects, there are more and more people involved, and it's important that people understand what they're expected to do, and what role they're expected to fill.

Just knowing a job title may not be all that helpful, as different companies give different names to the same job. In one company, someone doing a particular job may be called a Project Manager. In other companies, someone doing the same job may be called a Project Leader, a Team Leader, or a Program Manager. Conversely, in different companies, people with a particular job title may do very different things. For example, a company's expectations of a Product Manager may be very different in different companies (Fig. 7.9). And expectations of a Project Manager may be just as different.

Independently of their job title, or their job description, people may play several roles. For example, one person may, in one project, have the roles of Project Manager and Data Modeller. In another project the same person may have the roles of Team Leader and Business Analyst.

Roles may be assigned to one or more individuals. Conversely, individuals may play one or more roles.

7.2.3.1 Project Sponsor

The Project Sponsor has the most senior business role in the project, and is likely to be a high-level executive. This person is the customer for the project, and has

be a business leader for a product line
be a team member among many developing a new product
plan for new products, build product roadmaps, gather market requirements, identify new product candidates, develop business cases, define new products at a high level, plan and lead development projects, explain the product to Marketing and Sales
define the marketing message, promote the product at trade events, work with the press, monitor the competition

Fig. 7.9 Different expectations of a Product Manager in different companies

is responsible to ensure that project goals are achieved	take high-level decisions
assist with major issues, problems, and policy conflicts	chair the Steering Committee

Fig. 7.10 Typical activities of the Project Sponsor

ultimate authority and responsibility. The sponsor sets the project goals, appoints the Project Manager, agrees the initial plan, provides project funding and other resources, resolves issues and scope changes, approves major deliverables, and approves progress from one project phase to the next (Fig. 7.10). This person needs to be committed and available for the duration of the project. The likely involvement of the Sponsor in the project is about 4 h/week.

7.2.3.2 Stakeholders

In different projects, the term "stakeholder" has different meanings. At one extreme, the stakeholders are only the high-level executives whose departments, or other organisations in the company, will be impacted by the project. At the other extreme, the stakeholders are all the people or groups which may impact, or may be impacted by, or may otherwise have an interest, in the project. In view of this wide spread of meanings, it's important to define the exact roles and responsibilities of a stakeholder.

7.2.3.3 Steering Committee

A Steering Committee is usually a group of high-level stakeholders from the key organisations involved in the project. Their activities and responsibilities differ from one project to another (Fig. 7.11). The Steering Committee is usually headed by the Project Sponsor. The likely involvement of a Steering Committee member in the project is about 2 h/week.

In view of the differing roles of Steering Committees, it's important to define the exact roles and responsibilities of a Steering Committee.

7.2.3.4 Project Manager

The Project Manager is responsible for on-time, on-budget achievement of the project's goals. Typical activities are shown in Fig. 7.12.

resolve project issues related to their department	listen to progress reviews from the Project Manager
allocate resources to the project from their department	approve end-of-phase project deliverables
review and approve scope changes	assist in securing funding
liaise with executive groups	support the Project Sponsor in decision-taking

Fig. 7.11 Typical activities of the Steering Committee

receive direction from the Project Sponsor	monitor progress against plans
prepare the project plan and deliverables	report status and progress to the Steering Committee
carry out high-level scheduling	receive feedback from the Steering Committee
manage the project on a day-to-day basis	secure acceptance and approval of deliverables
manage project resources	raise issues with the Steering Committee
identify project team members	monitor contract compliance with external participants
coach team members	manage risks and issues
motivate team members to meet objectives	communicate with top management

Fig. 7.12 Typical activities of the Project Manager

7.2.3.5 Project Director

In large projects, there can be a lot of project management work. As a result, the Project Manager role is often shared between a Project Director and a Project Manager, with the Project Manager reporting to the Project Director. In this case, the Project Director usually addresses the more strategic issues and the communication with top management, while the Project Manager manages the day-to-day issues. If the project management role in a project is split, it's important to define the exact roles and responsibilities of the Project Director and the Project Manager.

7.2.3.6 Project Team

Project Teams come in various shapes and sizes. The Team may consist of people from just one functional organisation, although usually it consists of people from several functional organisations. There may be just one team. Or there may be a Project Team made up of several teams, such as a Core Team (of the people most involved) and an Extended Team (of less-involved people).

7.2.3.7 Project Team Member

A Project Team Member executes tasks and produces project deliverables. They may be assigned full-time or part-time to the project team. They may carry out a wide range of activities (Fig. 7.13).

Some Project Team members may not have participated in a project before. It's important to define their roles and responsibilities.

understand the assigned task	plan detailed activities
execute the assigned task	report status and concerns

Fig. 7.13 Typical activities of a Project Team Member

7.2.3.8 Team Leader, Track Leader

PLM Initiatives are major endeavours that may involve many people and many projects. Some of these projects may be grouped into a "Track" and assigned to a Track Leader (or Team Leader). The Track Leader reports to the Project Team Manager.

7.2.3.9 Subject Matter Expert

A Subject Matter Expert (SME) has excellent knowledge and experience of their particular subject (or area or topic). An SME provides expertise on their subject as required by project activities (Fig. 7.14).

7.2.3.10 Business Process Architect

A Business Process Architect may carry out numerous activities (Fig. 7.15). A Business Process Architect often develops and documents the future architecture of the company's business processes. This person also describes the current and future business processes of the company. The Business Process Architect monitors implementation of the processes and the process architecture. They may also assist in preparation of Use Cases.

As the exact activities of a Business Process Architect may not be clear, it's important to define this role and its responsibilities.

provide knowledge of a specific subject	participate in process modelling
provide expertise in a specific subject	participate in use case development
act as an authority on a specific subject	participate in data modelling
explain how tasks are currently executed	participate in defining tests
help people get their facts straight	participate in creating training materials
review documents before communication	participate in training activities
participate in process mapping	participate in workshops

Fig. 7.14 Typical activities of a Subject Matter Expert

map current business processes	identify process improvement areas
document the Business Process Architecture	model future business processes
work with executives to understand business vision	analyse business processes
describe business capabilities	create dashboards and scoreboards
capture business goals	communicate expected outcome of business improvement
identify KPIs to manage business goals	deploy and monitor business processes
discover business processes	continuously improve business processes
define business processes	document business processes

Fig. 7.15 Typical activities of a Business Process Architect

7.2.3.11 Data Modeller

A Data Modeller develops and documents data models for information systems corresponding to business requirements. Their activities are focused on data (Fig. 7.16).

7.2.3.12 Business Analyst

A Business Analyst understands and documents a business area and its activities, identifies and evaluates its business requirements, communicates with IS, and recommends solutions. The Business Analyst often carries out many activities (Fig. 7.17).

As the Business Architect may be called upon to carry out many activities, it's important to define this role and its responsibilities.

7.2.3.13 System Analyst

A System Analyst understands and coordinates system improvements to meet the company's business requirements. A System Analyst bridges the gap between a business need and the corresponding IS solution (Fig. 7.18). This role can easily overlap with others, so it's important to define clearly the role and its associated responsibilities.

understand frameworks and methods	identify data storage tools
understand and evaluate the current state of data	undertake data analysis
map current data structures	document data sources/targets
model the future state of data	document data integration
construct a detailed data model	document functional specifications
identify data migration strategies	identify data management tools

Fig. 7.16 Typical activities of a Data Modeller

understand the business strategy	communicate suggestions to the business
analyse business needs	communicate with system analysts
identify business requirements	write functional requirements
document business requirements	interpret business needs for IS staff
review current business processes	explain functional requirements to system developers
identify problem areas	work with IS to improve applications
design and document improved business processes	ensure IS delivers the required improvements
assess the impact of proposed changes	provide business training on the new solution

Fig. 7.17 Typical activities of a Business Analyst

interact with business analysts	manage a system development project
communicate with system users	write technical specifications
understand business requirements	create use cases
understand user requirements	help application developers
assess existing systems	participate in testing of the new system
interact with solution architects on future design	document the system

Fig. 7.18 Typical activities of a System Analyst

7.2.3.14 Solution Architect

A Solution Architect is responsible for the overall design, development and implementation of a future IS solution. In different projects, Solution Architects may carry out different activities (Fig. 7.19). It's important to define the exact roles and responsibilities of a Solution Architect, otherwise many people will wonder "what does that guy actually do?"

7.2.3.15 Application Developer

An Application Developer translates business requirements into a deployable application or application component. Application Developers usually have just a few activities in a project (Fig. 7.20), but without them, nothing will be implemented.

7.2.3.16 Key User

A Key User has an excellent understanding of the applications in a particular part of the business. Key Users apply their knowledge and understanding to support activities throughout the project (Fig. 7.21).

map business requirements to system requirements	write a functional design document to meet requirements
develop the overall vision of the solution	write a development specification
transform the vision to the solution	suggest best practice
communicate proposals to executives and developers	participate in training design and delivery
model business processes	monitor solution implementation

Fig. 7.19 Typical activities of a Solution Architect

design	model	create
test	document	deploy

Fig. 7.20 Typical activities of an Application Developer

provide business knowledge	support other users
provide organisational understanding	address simple problems
confirm business requirements	manage incidents
represent users from part of the business	contact the Help Desk
participate in testing	manage a list of issues
know details about the applications	collect improvements
train other users	propose improvements

Fig. 7.21 Typical activities of a Key User

7.2.3.17 Tester

A Tester carries out testing activities (Fig. 7.22). These could include creating test plans, carrying out tests, and reporting test results.

7.2.3.18 Workshop Facilitator

A Workshop Facilitator is responsible for organising the workshops that are held at various times during the project. Their expertise and activities lie in the organisation and execution of Workshops (Fig. 7.23). They aren't expected to be expert in the subject matter of a Workshop.

7.2.3.19 Project Assistant

A Project Assistant assists in the administrative duties of managing the project (Fig. 7.24). Like the Workshop Facilitator, they aren't expected to be experts in the subject matter of the project.

7.2.3.20 Project Coach

A Project Coach is responsible for the correct use of the correct tools and methodologies in the project. As there may be confusion between the roles of trainer, coach and mentor it's best to clarify the expected activities of the coach (Fig. 7.25).

create test plans	carry out testing	define cases
define test scenarios	document tests	report test results

Fig. 7.22 Typical activities of a Tester

define workshop scope with workshop owner	understand areas of concern in the subject
clarify workshop objectives	define workshop preparation work
plan the workshop	facilitate the workshop to meet its objectives
understand the subject area of the workshop	ensure workshop results are documented and communicated
identify suitable workshop participants	review workshop against objectives

Fig. 7.23 Typical activities of a Workshop Facilitator

organise meetings	maintain project support technology
organise travel	assist team members in use of technology
organise events	handle project logistics
organise facilities	attend meetings and take minutes
maintain and update project Intranet	manage timesheets

Fig. 7.24 Typical activities of a Project Assistant

provide detailed knowledge and experience	help the team work in the required way
help the team to use unfamiliar practices	build capability in the team
ensure team members understand tools and methodologies	answer queries promptly

Fig. 7.25 Typical activities of a Project Coach

7.2.4 Project Phases

There are often four high-level phases in a project. The names of these phases vary from one company to another and from one project to another. As an example, they could be referred to as the Initiation, Planning, Monitoring and Controlling of Execution, and Closure phases. Typical Phase 1 project management activities are shown in Fig. 7.26.

7.2.4.1 Phase 1 Project Management Activities

Phase 1, “Initiation”, is the phase in which the aims of the project are defined and agreed. The activities carried out in this phase vary from one project to another. A Project Document is developed to describe the project in detail. A Business Case may be created to show expected costs and benefits of the project.

7.2.4.2 Phase 2 Project Management Activities

Phase 2, “Planning”, is the phase in which the project is planned. As for the Initiation phase, the activities carried out in this phase vary from one project to another. Examples of possible Phase 2 project management activities are shown in Fig. 7.27.

7.2.4.3 Phase 3 Project Management Activities

Phase 3 is “Monitoring and Controlling of Execution”. It includes the Project Management activities that are carried out while the project is being executed

assign the Project Manager	clarify the acceptance criteria for the project
confirm project sponsorship and stakeholders	define major phases and deliverables
confirm the project scope and objectives	define a timeline including start, end and intermediate dates
identify business expectations in cost and time terms	draft a high level plan
determine required and available resources	create a formal Project Document
identify any constraints	develop a Project Charter
develop the business case	develop a mission statement
create the Project Team	prepare deliverables for review
define project roles and responsibilities	carry out an end-of-phase review
clarify the project’s control and reporting structure	get agreement to continue to Phase 2

Fig. 7.26 Typical project management activities in Phase 1

identify the main parts of the project	refine the detailed task list
identify the tasks in each main part of the project	develop an initial Project Schedule and budget
include activities for externals: software vendors, consultants	conduct risk assessment with team members
include activities for issue and risk management	discuss the Schedule with sponsor and stakeholders
include activities for communication	adjust the Project Schedule
include activities for training	review assignments with each team member
include project meetings	assign resources
include management decision-taking activities	carry out an end-of-phase review
for each task, estimate time, identify resources and dependencies	get agreement to continue to Phase 3

Fig. 7.27 Typical project management activities in Phase 2

(Fig. 7.28). There's a lot going on in the project at this time (for example, design and build of solutions). But from the Project Management view, there are relatively few tasks in Phase 3.

7.2.4.4 Phase 4 Project Management Activities

In Phase 4, "Closing", the project is brought cleanly to an end. Typical project management activities in this phase are shown in Fig. 7.29.

7.2.5 Project Management Knowledge Areas

According to the Project Management Institute, project management knowledge draws on ten areas (Fig. 7.30).

The subjects of most of these areas are self-explanatory from their names. Two names that may not be so clear are Integration and Procurement. The Integration area addresses subjects such as coordination and control of project planning and execution, and management of changes to the plan. The Procurement area covers subjects such as acquisition and management of products and services needed for the project from outside the company.

review project progress	keep stakeholders informed
update project status	revise plan as required
monitor risks, take action as necessary	prepare deliverables for review.
ensure quality	carry out an end-of-phase review
identify and manage issues	get agreement to continue to Phase 4
report progress to Steering Committee	hold project meetings

Fig. 7.28 Typical project management activities in Phase 3

close-out final tasks and issues	transition to support/service mode
conduct final project review	conduct project retrospective
conduct sponsor sign-off	capture and document lessons learned
complete and archive project documents	celebrate success

Fig. 7.29 Typical project management activities in Phase 4

Human Resources	Quality
Communications	Scope
Procurement	Time
Stakeholder Management	Cost
Integration	Risk Management

Fig. 7.30 Project management knowledge areas

7.2.6 Project Management Tools and Templates

Many techniques, tools and templates are available to help people manage projects and achieve project success. The following are among those most frequently used.

7.2.6.1 PERT, PERT Chart

PERT (Program Evaluation and Review Technique) is a technique used to represent and analyse the tasks of a project. A PERT chart is a graphical network model that depicts a project's tasks and the relationships between those tasks.

7.2.6.2 Gantt Chart

A Gantt chart is a horizontal bar chart that shows project tasks against a calendar. Each bar represents a named project task. The tasks are listed vertically in the left-hand column. Time is on the horizontal axis. The start date and the end date of each task are shown.

7.2.6.3 Project Management Software

Project management software can be used by the Project Manager for a variety of purposes. For example, to plan and schedule project activities, allocate and manage human resources, support decision-taking, manage costs and budgets, document and communicate project progress.

7.2.6.4 Deliverables Checklist

A Project Deliverables Checklist shows the required project deliverables and the targeted delivery date for each deliverable.

7.2.6.5 Roles and Responsibilities Matrix

In each project, it's important for everybody to understand their roles and responsibilities. They should also understand those of the other participants. The purpose of the Roles and Responsibilities Matrix for a particular project is to define the roles and associated responsibilities for that project.

7.2.6.6 Risk Log

A risk is an event that, if it occurs, can impact a project. A Risk Log is a table (e.g., in Excel) showing open and resolved risks of a project. There's a row for each risk. The columns of the table contain basic information about the risks. Examples of column headers are: Risk number; Risk name; Risk description; Risk author; Risk type; Risk severity; Risk likelihood; Date that Risk identified; Risk assigned to: Deadline date; Date of Resolution; Risk status; Actions taken.

7.2.6.7 Risk Matrix

A Risk Matrix is a simple two-dimensional matrix. It's used to provide visibility about a risk, and to help ranking of risks and decision-making. The horizontal axis of the Matrix shows the Probability (P) of a Risk occurring. The y-axis shows the Severity (S) of the risk if it occurs. The matrix shows predefined risk levels corresponding to a small number of values of P and S.

Usually four or five possible values of Risk Probability are included in the matrix, for example, Certain, Likely, Possible, Unlikely and Rare. And usually four or five values of Risk Severity are included in the matrix, for example, Catastrophic, Critical, Marginal, and Negligible. Usually the matrix shows a small number of risk levels, for example, Low, Medium, High.

7.2.6.8 Risk Management Software

Risk management tools provide IS support to project managers in their task to identify, describe, classify, prioritise, document and track risks. Probabilities and levels can be set. Risks can be assigned for response, and responses tracked. KPIs can be calculated. Reports can be generated.

7.2.6.9 Issue Log

An Issue is an event that has occurred and can have an impact on the project. An Issue Log is a table (e.g., in Excel) showing open and closed issues of a project. There is a row for each issue. The columns of the table contain basic information about the issues. Examples of column headers are: Issue number; Issue name; Issue description; Issue author; Issue type; Issue priority; Date that Issue raised; Issue assigned to: Deadline date; Date of Resolution; Issue status; Actions taken.

7.2.6.10 RACI Diagram

RACI is an acronym for Responsible, Accountable, Consulted, Informed. A RACI matrix communicates to everybody in the project, for every task, who is responsible, who is accountable, who has to be consulted and who has to be informed.

7.2.7 KPIs for Project Management

A Key Performance Indicator (KPI) is a quantifiable attribute of an entity or activity that helps describe its performance. KPIs for project management (Fig. 7.31) help a company to set targets for project management activities and measure their progress.

7.2.8 The Importance of Project Management in PLM

Project Management is important in PLM because cross-functional, enterprise-wide projects such as PLM Initiatives are known to have high failure rates. It's not easy to get people from many different parts of a company to work together. Good Project Management will help make it happen.

Many of the reasons for failure are linked to poor project management. There are many types of failure. Examples include failure to deliver on promises, failure to keep within budget, failure to report meaningfully, failure to develop accurate specifications, and failure to get people to change their behaviour.

7.2.8.1 What's Special About Project Management in the PLM Environment?

Although the project management of all enterprise-wide projects is challenging, PLM Initiatives have many special characteristics (Fig. 7.32) that can exacerbate the situation.

customer satisfaction	phase achievement accuracy
cost performance / variance from planned budget	percentage of milestones missed
time performance / deviation from planned cycle time	number of scope changes
time performance / deviation from planned workdays	requirements performance

Fig. 7.31 KPIs for project management

PLM Initiatives run over a very long period
there can be very many projects and sub-projects in a PLM Initiative
PLM addresses a very wide scope
PLM addresses many hard issues and many soft issues
successful PLM involves significant organisational change
generic Project Managers may be out of their depth in the details of PLM
confusion between PLM and Project Lifecycle Management (PLM)

Fig. 7.32 Special characteristics of project management in the PLM Environment

7.2.8.2 What Happens if You Don't Do Project Management in a PLM Initiative?

It's unlikely that a company would try to carry out a PLM Initiative without some form of Project Management. The question should perhaps be "What happens if you don't do Project Management in a PLM Initiative well?"

Many PLM Initiatives fail. Some sources cite failure rates as high as 50 %. Failure is rarely due to the quality of a particular new process or the functionality of a new application. Usually it's due to the way that these are implemented, which in turn is a consequence of the way the project is managed. The likely consequences of poor Project Management in the PLM Initiative are serious (Fig. 7.33).

7.3 Project Reality in a Typical Company

7.3.1 Generic Issues with Projects

In a typical company, there will usually be many issues with projects in the PLM environment (Fig. 7.34).

Companies define the scope of their projects, and name them as they like. Often the name is misleading and creates confusion as to the real objective. Often project objectives aren't clearly defined. Again the result is confusion. There is often

projects come in late	the Project Manager resigns
projects lead to incorrect results	Team Members are fired
projects give partial results	Team Members are reassigned
management is unhappy	PLM is seen as a failure
the PLM Initiative fails	PLM is seen as bureaucratic

Fig. 7.33 Consequences of poor project management in the PLM Initiative

objectives	scope	KPIs
resources	overrun	fracture
commitment	processes	governance

Fig. 7.34 Examples of project management issues in the PLM environment

unclear objectives	scope creep
Project Management guidelines ignored	inappropriate support technology
insufficient team resources	project takes on a life of its own
unclear scope and business need	poor project start-up
objectives not clear	team members run wild
uncommitted sponsor and stakeholders	weak business case
poor communication	accountabilities ignored
expected benefits not clearly defined	benefits not achievable

Fig. 7.35 Other issues with projects

duplication or overlap of activities between different projects. Boundaries between projects are rarely defined. Project Governance may not be clearly defined. Roles and responsibilities may be vague. As a result, nobody feels really responsible for the project. If any problems arise, no-one's there to put things right. There may be no KPIs in some projects. In other cases, the wrong performance measures are used to measure progress.

Sometimes, the Project Management processes in a company haven't been defined. If they have, there may be no management commitment to ensure that they're followed. The processes may be poorly defined, and poorly documented with a resulting lack of clarity about what should be done. There may be no training about processes. There may be no management system to ensure that Project Management processes are continually improved.

In addition to the above problems, it's not uncommon for other issues to arise (Fig. 7.35).

7.3.2 Generic Issues with Project Plans

Just as there are generic issues with projects, there are also generic issues with project plans (Fig. 7.36). As time passes, and the project evolves, project plans will change, resulting in several versions of the plan. But there may be no management system for changes to project plans. As a result, some people may work to the latest version of the plan, while others continue to work to the previous version, leading to confusion and errors.

confusion about terms such as milestones	insufficient time allocated for planning
wide variation in the size of tasks	estimates are not fact-based
wide variation in the level of detail planned	over-ambitious timeframes
no review of plans	estimates assumed without justification
company goals not understood by planners	interdependencies not understood
plans are for too much too soon	insufficient planning
poor financial estimates in plans	contingency not included
plans made without enough data	project estimates are best guesses
planners don't know about people's skills	project estimates not based on history
planners don't know about people's availability	working to different versions of the plan
planners not understanding project objectives	planning process not defined

Fig. 7.36 Generic issues with project plans

"Product Development is innovation. You can't make plans about Innovation"
"I have no time to make a plan, I'm overloaded with project work"
"My project tasks depend on other people's efforts, so I can't plan them"
"All this bureaucratic planning stifles innovation and the real work"

Fig. 7.37 Objections to project plans

Project plans may be poorly defined, and poorly documented. They may be so unclear that they can't be understood by people working in the project.

A project plan may be split into several parts, each the responsibility of a different person. As these people focus on developing their part of the plan, they may ignore its interactions with other parts. In the part that they are developing, they may include activities that are already in other parts of the plan. This can lead to redundant effort across the project.

To develop and document the plan quickly, Project Managers may use their PM jargon. However, that will make it more difficult for other people, not trained in PM terminology, to understand what's happening. And busy Project Managers may not have time to define the purpose of each task in the plan, or its scope, or even make sure that it has an owner.

Another issue that project plans may face is resistance from conscientious objectors, who object to project plans on grounds of freedom of thought and action (Fig. 7.37).

7.3.3 Interaction with Other Activities

The Project Management activities of the PLM Initiative aren't an island isolated from the rest of the Initiative and the rest of the company. They're at the heart of the Initiative and bring together all the other activities.

In addition to the PLM Initiative, most companies will also have several other initiatives running. Company initiatives address many different subjects, and include many improvement activities. Each initiative will have its plans. It's not unusual to find duplication or overlap of activities between different initiatives. To avoid potential problems, it's important to identify the other company initiatives and find out if and how they may interact with the PLM Initiative. And then work out how to harmonise management of overlapping and closely-related activities.

7.4 Project Management Activities in the PLM Initiative

A PLM Initiative takes a company from its current PLM situation to a desired future situation (Fig. 3.32). All PLM Initiatives have to be managed.

7.4.1 Projects Related to Project Management

In PLM Initiatives, there are many projects addressing business processes, product data, PLM applications and organisational change. All of these will be managed by the Project Management activities (Fig. 7.38) of the Initiative.

Most projects in a PLM Initiative will be cross-functional and include people from across the product lifecycle. However, people coming from different backgrounds may have very different understandings of the terms used in Project Management. So it's useful to develop a glossary that gives short definitions of these terms. This will help everyone to understand the terms and should lead to a common understanding of the subjects to be addressed.

Similarly, some of the people in the Initiative may know little about Project Management. Many of the members of the project team may not have participated before in a cross-functional project. In such circumstances, it can be difficult for them to know how best to execute their activities and go about their work. As a result, some training about Project Management will be useful.

7.4.2 Working with Consultants

It can be difficult for a manager of a company's PLM Initiative to manage people who work for the company. It can be even more difficult to manage people who work for partners. Many problems can arise with consultants. For example, they may lack experience, they may take longer than necessary on the job to get paid more, they may do other tasks than the one they were hired to do, and they may produce non-value-adding voluminous reports. And, to cover up their inadequacies, they may blame the person who hired them for any difficulties that arise.

To avoid these problems, the project manager should, first of all, define exactly what the consultant has to do, the number of days work, and the maximum that can be paid. Proposals should be requested from several consultants. The project manager should meet and test the consultant they're going to work with. There's no point in meeting the consultancy's salesperson. They're not going to do the work. Similarly there's no point in buying a brand name. In consultancy, all that matters is the particular individual you work with. The project manager should make sure that the consultant really knows the subject, and should check out references of previous similar consultancy work.

plan activities related to Project Management	manage the Initiation phase
develop a Project Management Glossary	manage the Planning phase
provide Project Management training	manage the Monitoring and Controlling phase
define KPIs for the project	manage the Closure phase

Fig. 7.38 Examples of activities related to project management

The project manager should make sure that, every day, the consultant writes down exactly what has been done that day. This way, the project manager can check that the consultant is doing exactly what is wanted, and that the company isn't paying for work that's not required. If there are several phases to the work, the project manager may consider getting a different consultant for each phase. This should prevent consultants from structuring the next phase so that they will have a lot of work to do, as that will mean a lot to pay.

The project manager should make sure the consultant brings something useful, such as knowledge or experience, to the rest of the team, and should make sure it gets transferred. The project manager should make sure the consultant doesn't start managing the project team and changing the project plan. If possible, the project manager should avoid hiring more than one consultant at a time. It's much more difficult to manage several. If the project manager does have to hire more than one, they should be kept apart. The project manager should remember that they will be alone as soon as the consultant has spent the budget. If there are problems after the consultant has gone, the project manager, and not the consultant, will be blamed.

7.4.3 Reviewing Readiness

There are so many issues for a PLM Initiative Manager to address, that 'wait' and 'think' are among the best recommendations. Before rushing off to fight the first fire that shows up, PLM Initiative Managers should slow down and make sure they really know where they are and where they're going. They will never succeed if they don't start from the right place and don't know where they're going. They can test their readiness with some questions (Fig. 7.39).

your objectives	are they clear and documented?
	is there consensus about the objectives?
your targets	are there clear targets for this year?
	are there approximate targets for coming years?
project plan	is it documented and agreed?
	has it been communicated?
plan tasks	are they clearly defined?
	are you sure they aren't open to misinterpretation?
plan tasks (2)	are you sure no-one has redefined them without telling you?
	are you sure they don't conflict with other tasks?
project team	do team members have the required skills?
	will team members work hard?
the sponsor	does the Sponsor have the power for you to win through?
	are you sure the Sponsor's support won't waver?
the budget	is your budget clear and agreed?
	is there enough money in case something goes wrong?
the scope	has the project scope been clearly defined?
	are you sure you can handle the scope?
training	has everyone been sufficiently trained?
	are you sure that no-one will cut your training budget?

Fig. 7.39 Readiness questionnaire

Questions like these are helpful. As Rudyard Kipling put it:

I keep six honest serving-men
(*They taught me all I knew*);
Their names are What and Why and When
And How and Where and Who.

You can learn a lot from good questions if you take the time to answer them. Initiative Managers should be able to answer ‘Yes’ to each question. If they can’t, then before rushing to the next meeting or diving to the nearest workstation, they should just wait a moment. They should take some time to plan what’s really needed for the next few months instead of trying to solve whatever appears to be the very urgent, very important task for the next few hours. There will always be another very urgent, very important task waiting after this one. Solving one very urgent, very important task after another is rarely the most effective way to work. Take the time to organise and plan your work. You’ll probably find that the number of very urgent, very important tasks decreases, and you’ll have the time you need for the tasks that are on the critical path to your objectives.

7.4.3.1 Success Factors for Project Management

Project Management activities in the PLM environment are likely to be challenging. Some success factors for these activities, drawn from experience in many Initiatives, are shown in Fig. 7.40. Understanding these can put, and keep, the Initiative on a good track.

7.4.3.2 Benefits of Project Plans

The benefits of a good project plan can also be identified from experience in many Initiatives. Some examples are shown in Fig. 7.41. A good project plan is one of the most important components of a PLM Initiative.

clear Business Case and Objectives	motivated Project Team
good Project Sponsor	one Project Manager throughout the project
agreed project acceptance and success criteria	good Risk Management
good planning, a good project plan	including 15% contingency in plans
clearly defined roles and responsibilities	avoiding project creep
good communication between participants	closing the project with a clear cut-off
experienced Project Manager	structured approach to learning from experience
good understanding of roles and responsibilities	appropriate KPIs
early success	common vocabulary

Fig. 7.40 Success factors for project management in the PLM environment

gives a better understanding of future activities	reduces problems downstream
leads to a more realistic time-scale	details resource requirements
leads to more accurate cost estimates	provides early warning of task slippage
a basis for identifying best practices and templates	keeps everyone aware of progress
identifies project milestones and deliverables	helps stop things slipping off the radar

Fig. 7.41 Benefits of a good project plan

7.5 Learning from Experience

From experience in many PLM Initiatives, lessons have been learned about success factors and potential pitfalls. It's good to be aware of both, and to avoid the latter.

7.5.1 From the Trenches

The following examples show the kind of issues related to project management that arise in PLM Initiatives.

7.5.1.1 Workshops on Christmas Day

One company that I was working with received a proposal for assistance from a consultancy that included a file with more than 3000 lines of detailed project plan. The Project Manager was impressed and said this showed that the consultant was taking the project very seriously. I had my doubts, believing that few projects benefit from 3000 lines of project plan. I looked at the plan and saw most of it had been created with copy and paste, and hadn't even been given a reasonability check. The Project Manager was less impressed with the proposal after I'd shown how (on lines 1734–1924) the consultants would be working seven days a week throughout the project, and had even planned (line 2457) to hold workshops with the company's Subject Matter Experts on December 25.

7.5.1.2 Changing Horses in Midstream

As part of their process of selecting an adviser for a project, many companies ask consultants to participate in a "Beauty Contest". At one particular company, the Project Manager who organised the event had a background in Project Management and Process Improvement, which probably helped us win the Contest. However, by the time the PLM project actually started, about 6 weeks later, this person had left the company, to be replaced by two Project Managers. One of these had a pure IS background, the other a pure Engineering background. Neither had experience in Project Management, or in Process Improvement. The project was planned to run for a year, but after another 6 weeks, we were out. The change of Project Manager had resulted in a change of project.

7.5.1.3 Kill Jimmy Meetings

It's really important to keep the same project manager throughout a project. A good Project Manager is the life and soul of a project. Replace them with someone else, and expect to lose not just time but also good team members. In one company that we were working with, I knew that Jimmy, the Project Manager, wasn't happy with the way the Steering Committee was behaving. As is often the case, the role and responsibilities of the Steering Committee hadn't been clearly defined. According to Jimmy, his monthly meetings with the Committee had become "Kill Jimmy" meetings. One Monday morning he arrived in the office, and announced that he'd resigned and his last day was Wednesday (he had vacation days due). It took several months to get the project back on course. Fortunately, the Steering Committee realised what had happened, and the monthly meetings became "Support Mary" meetings.

7.5.1.4 Non-participating Project Members

In an automotive company, the PLM Project Manager had a different problem with the Steering Committee. Several members of the project team didn't contribute to the project. When the Project Manager asked why, they replied that their departmental managers (members of the Steering Committee) had told them not to. When the Project Manager raised the subject at the next Steering Committee, he was assured that everyone was fully committed and expected to contribute to the full. However, several members of the project team continued not to contribute.

7.5.1.5 Revolving Door Project Managers

Project Managers in a PLM Initiative may have a short life. In an extreme case, one PLM Initiative that I was working with had 5 Project Managers in less than 18 months. That's an average life of less than 4 months. Not surprisingly, it became increasingly difficult to find the next Project Manager. And, not surprisingly, the project didn't progress as quickly as expected.

7.5.1.6 The Project Manager Who Wasn't

In one assignment, with a machine manufacturer, the PLM Project Manager found a solution to the pressure of being a PLM Project Manager. First though, some important information. The company had several thousand employees and was present in more than 40 countries. And the project was in its initial phase, which only addressed the main R&D and Manufacturing site. The solution that the PLM Project Manager had found was to say that he wasn't the PLM Project Manager. He and the other team members knew each other well and worked well together. The first phase of the project was completed successfully. However the next phase involved roll-out to other sites. The role of PLM Project Manager would become very visible. So he left the company.

7.5.1.7 Moving the Goalposts

In another assignment, the PLM Project wasn't making headway as quickly as expected. There were so many details to address that progress wasn't as fast as everyone wanted. The PLM Project Manager thought he was being blamed for not moving forward fast enough. To speed things up he changed the end-of-phase criteria to make acceptance more likely. The phase was accepted, but the Project Sponsor found out what had happened. And took him off the project.

7.5.1.8 An Unsupportive Sponsor

The relationship between the Project Sponsor and the Project Manager is important, but can also be a source of problems. On one assignment, our first invoice was paid promptly, but not the second. It turned out that the Project Manager wanted us to work on the project, but hadn't succeeded in convincing the Project Sponsor to provide funding. The project was terminated.

7.5.1.9 Happy Birthday, Dear Project

In one company, the project was so far behind target, that the Project Sponsor sent the Project Manager a "birthday card" on the first anniversary of the original end date.

7.5.1.10 Hierarchical Problems

Working with another company, the Project Sponsor had chosen a Project Manager who was relatively junior in the hierarchy. Although he worked well, many hierarchically more senior team members wouldn't take direction from him. The project ground to a halt.

7.5.1.11 Get Dirty Quickly (1)

"Get Dirty Quickly" was the project management mantra of one Project Sponsor we worked with. Instead of wasting time on planning, he wanted the team members to start working and making progress. After a few months, the project stopped. It hadn't made any progress. Maybe this approach works if project objectives are clear and team members are trained to work this way. However, in this case, the objectives weren't clear and the team hadn't been trained.

7.5.1.12 Get Dirty Quickly (2)

In one project, the Project Manager was so keen on making rapid visible progress that he purchased an expensive machine without fully analysing the requirements. The machine was installed, and ready to go, but never used. The Project Manager was replaced.

7.5.1.13 Get Dirty Slowly

In another project, the Project Manager was so unwilling to make mistakes that, by the time the decision to buy a particular machine had been taken, the machine was no longer available. The Project Manager was replaced. A significant part of the project was repeated.

7.5.1.14 Would You Repeat That, Please?

Sometimes, it's not clear how companies create their PLM project plans. One automotive company selected a PDM system and installed licences. Then the Project Manager contacted us and asked us to help them implement PDM. Another organisation took a similar approach. After their PDM project team had selected a PDM system, the Project Manager asked us to give the team some training about PDM.

7.5.1.15 Project Management Fracture

Sometimes Project Management fracture occurs in a PLM Initiative. The Project Sponsor gets increasingly concerned as milestones are missed, and project team members are overloaded with planned work as well as trying to catch up on tasks that are running late. Meanwhile the Project Manager organises meetings to explain the finer details of Project Management to the team. In one project, this led the Project Sponsor to tell the Project Manager, "all this Project Management theory is great, but from now on, please focus on the real work".

7.5.1.16 Sinking Project

Another issue that arose in a project was that most of the team members didn't have the skills to make the project succeed. During the first two phases we repeatedly warned the Project Manager about this, and that he needed to find a solution. Plugging the holes, we managed to keep the project afloat. He didn't look for a solution, let alone find one. Early in Phase 3, the Project Sponsor stopped the project.

7.5.2 Pitfalls of Project Management

Project Management is an essential activity in PLM Initiatives. From experience in many Initiatives, lessons can be learned about success factors (Fig. 7.40). Experience can also be used to identify the potential pitfalls for Project Management in a PLM Initiative (Fig. 7.42). It's good to be aware of them, and then avoid them.

7.5.3 Top Management Role with Project Management

7.5.3.1 Guidance About Goals and Changes

Top management sets the project goals. The Project Manager is expected to make sure that the goals are achieved. It's important that the Project Sponsor takes the time to make sure that the Project Manager really does understand the goals. And if the Project Sponsor makes any changes to the goals, it's important that these are fully understood by the Project Manager. The goals of the Initiative need to be articulated in a clear, confusion-free and concise manner. Clear goals will be better understood by the Project Manager. They also make it easier for top management to track progress and make sure the goals are achieved.

lack of commitment from the Project Sponsor	expected deliverables not detailed and documented
no clear project objective	poor planning, unrealistic plan
project so big that it's unmanageable	insufficient resources (time, people, money, ...)
project scope too wide	no formal management of changes to the project
wrong make-up of the project team	poor risk management
wrong Project Manager, weak project leadership	poor project control and reporting
Project Team roles not detailed and documented	over-reliance on output of project management software
poor communication between project participants	scope changes
vague task descriptions in the project plan	Steering Committee role and responsibilities not defined

Fig. 7.42 Pitfalls of project management

7.5.3.2 Encourage Project Planning

It may seem unnecessary to create a project plan. However, as President Eisenhower put it, “In preparing for battle, I have always found that plans are useless but planning is indispensable.” Planning is useful. Discussing what’s needed, and anticipating what could happen, helps to avoid pitfalls, focus on important activities, and carry them out in the most effective way. Good planning reduces waste as it identifies exactly what is needed for each task.

Planning is important, even though it’s very unlikely that activities will occur 100 % according to plan. As Robert Burns put it,

> The best laid schemes o’ mice an’ men
> Gang aft agley,
> An’ lea’e us nought but grief an’ pain

7.5.3.3 Only Start with a Good Chance of Success

Top management shouldn’t start the project unless it’s very clear, at launch time, that there’s a good chance of success. Project failure will waste time and money, disrupt everyday business, and demotivate a lot of people. If it’s not clear that the project will succeed, then wait a while. Situations change and will be looked at differently. Come back to the subject of PLM when the likelihood of success is higher.

7.5.3.4 Create an Appropriate Organisation

Top management should make sure that the project is correctly organised and staffed. Top management is much better equipped to do this than the people in the project.

7.5.3.5 Get Involved and Stay Committed. Take Responsibility

In today’s highly competitive global environment, many business executives feel that they’re already overloaded with responsibility and work. They may not want to get involved with a subject such as PLM that can seem unclear in both scope and potential benefit. And the enterprise-wide character of PLM may lead them to decide that it doesn’t lie in their particular domains of responsibility. However, due to the enterprise-wide scope of PLM, it’s at the top management level that action has to be taken if the expectations of PLM are to become reality.

Top management involvement and commitment are key success factors in a PLM Initiative. Top managers should track project progress, and ensure the project stays on track, on time, on budget and on scope. If things aren’t working, they should take action to put the project back on track. If the project faces a major issue, top management must take responsibility and take charge.

7.5.3.6 Support and Develop the Project Manager

The Project Sponsor should select a suitable Project Manager, then provide feedback and support. They should create a partnership with the Project Manager so they both know what needs to be achieved and how to achieve it. The Project Sponsor should create a shared understanding about goals, and inspire the Project Manager to success. The Project Sponsor will only benefit by developing the Project Manager's capabilities to solve problems and make decisions. The more the Project Manager can do, the less the Project Sponsor will need to do.

7.5.3.7 Champion the Project at the Executive Level

The Project Sponsor should sell the project to stakeholders at executive level, and convince them of the PLM vision and strategy. Information about the Initiative and its goals should be shared. The Project Sponsor should network on behalf of the Initiative with Steering Committee members and other executives.

Chapter 8
The PLM Initiative

8.1 This Chapter

8.1.1 Objective

The objective of this chapter is to give a basic introduction to PLM Initiatives. This will help those involved in a company's PLM Initiative to participate more fully. This chapter also aims to give students a basic understanding of the aims and activities of a PLM Initiative.

8.1.2 Content

This chapter addresses the launch and continuation of a PLM Initiative. The first part of the chapter addresses the steps that lead up to a PLM Initiative. The second part addresses the launch of the Initiative and some post-launch activities. The third part of the chapter builds on experience of working in PLM Initiatives with many companies. It shares lessons learned from this experience. Examples are given of frequently-occurring situations. Common features of PLM Initiatives are described. Pitfalls are outlined. Top management's role in the PLM Initiative is addressed.

8.1.2.1 Skills

This chapter will give students, who've been assigned this book, a basic understanding of PLM Initiatives. They'll learn about typical activities in an Initiative. They'll be aware of some companies' experiences with PLM Initiatives. And they'll be able to explain, communicate and discuss about a PLM Initiative.

J. Stark, *Product Lifecycle Management*, Decision Engineering,
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8.1.3 Relevance

Many things happen in a PLM Initiative. Previous chapters have focused separately on activities addressing business processes, product data, PLM applications, Project Management and Organisational Change Management. Projects in these individual areas may be complex, involving many people, decisions, roles, costs and dependencies. In a PLM Initiative, activities related to all of these Five Pillars of PLM take place. Many of them overlap, or run in parallel. When they are combined in a PLM Initiative, the situation becomes even more complex. The whole is more than the sum of its parts. It's useful to understand the steps that companies take to create a PLM Initiative and to see some of the resulting experience.

8.2 Definitions and Introduction

8.2.1 Definitions

8.2.1.1 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. The other objective is to put in place, or to improve, the capability to manage products across their lifecycles.

8.2.2 From 5 Pillars to the Initiative

Previous chapters looked at the 5 Pillars of PLM (business processes, product data, PLM applications, Project Management and Organisational Change Management) as if they were separate. For each pillar, many typical projects were outlined. In total, more than a hundred were mentioned. Figure 8.1 shows thirty-two of them, so about 70 % of them are not shown.

Even with just thirty-two projects from the five areas, many questions will arise (Fig. 8.2).

define Use Cases	cleanse product data	map the current process	manage the Planning phase
mentor executives	migrate product data	define product data KPIs	define new business processes
create workflows	manage project risks	manage the closure phase	align change expectations
prepare new roles	plan roll-out strategy	model the future process	maintain PLM applications
coach Team Members	define Initiative KPIs	plan roll-out activities	develop a process glossary
define process KPIs	implement a PDM system	plan training activities	develop new reward systems
plan OCM activities	harmonise applications	restructure product data	manage Initiative start-up
select a PDM system	develop an OCM glossary	communicate about changes	create new job descriptions

Fig. 8.1 Typical activities from the five pillars

what do we start with?	how much overlap is there?	how long will the Initiative run?
can we prioritise?	how can we best use our team?	do executives understand the Initiative size?
which ones have we done?	can we combine some projects?	do we have a watertight business case?
which can run in parallel?	are there fixed dates to meet?	can we copy another company's Initiative?

Fig. 8.2 Questions about activities in the initiative

The answer to the question "can we copy another company's Initiative?" is "No". All PLM Initiatives are different, their details depend on all sorts of factors.

8.2.2.1 Different Company, Different PLM Initiative

PLM Initiatives will be different in different companies because companies are in very different situations when they start their Initiatives (Fig. 8.3).

There isn't a single, off-the-shelf, PLM Initiative that will fit all companies. Without knowing the exact situation within a company it's not possible to know what its Initiative should entail. This can be demonstrated by considering two companies (Company A, Company B) of similar size and supply chain position supplying similar products to similar OEMs in their industry. Company A reports that it's reduced its Engineering Change time by 80 % by implementing a new PLM application. What reduction do you think Company B can achieve by implementing that PLM application?

The answer, of course, is that it's impossible to give a meaningful answer. What really happened in Company A? Is the 80 % reduction due to implementing an application or was it due to improving the business process? Was the process previously manual or already automated? Does the reduction apply to all products or just to one? Does it apply to all sites or just one? And how does the environment in Company B relate to that in Company A? Has Company B already implemented that PLM application? In which case it may already have achieved a 90 % reduction in Engineering Change time.

The PLM Initiative in one company may be different from that of another just because of the different span of activities. One company may only provide design services, and focus on the development phase of a product. In its view, the main activity of PLM may be the use of 3D CAD applications. Another company, such as an aircraft manufacturer, may be involved with its products across their entire lifecycle, which could be more than 50 years. In addition to applications, it may have a much wider scope of PLM, also including business processes and product data.

companies are in different industries with different products, such as aircraft and chocolates
companies have different positions in the supply chain, such as an OEM or a Tier 3 supplier
companies are at different maturity levels of PLM implementation
companies have different levels of PLM awareness, and different skills
companies can have very different business objectives, and different reasons for starting the Initiative

Fig. 8.3 Different situations when starting a PLM initiative

8.2.2.2 Differences Between Industries

PLM is used in a wide range of industries. There are many differences between these industries, and they have different PLM needs and priorities. As a result, although PLM is used in many industries, it's implemented and used differently in different industries.

For example, in the automotive sector, companies must bring innovative new products to market frequently. They must also cut costs and improve productivity. Product Development is seen as a key activity to achieve these targets. As in the aerospace industry, the definition of product geometry data has high priority in automotive companies. Collaborative Product Development plays an important role because of the high level of outsourcing and offshoring. Other components of PLM help maximise the reuse of components, parts, and assemblies. Automated workflows speed up processes such as Production Part Approval Process (PPAP) and Advanced Product Quality Planning (APQP), and ensure compliance. European Directives are leading car companies to manage the end of life of the product better. Companies across all tiers of the automotive industry implement PLM to speed time to market, reduce costs and increase new business achievement rates (Fig. 8.4).

Companies with long lifecycle products, such as aircraft and power plants, focus on configuration management to support future access to data about the products. These products are often highly complex, with electronic, software and electro-mechanical components. There are regulatory requirements for data retention and auditing. In aerospace companies, configuration management plays an important role. Workflows speed up design reviews and change management. Collaborative Product Development is important in this industry as development work is often shared between several companies in different countries. Conformance with European Aviation Safety Agency (EASA) and Federal Aviation Administration (FAA) requirements is needed.

In many high-tech industries, companies aim to be market leaders by bringing innovative new products to market before competitors. They need short development cycles and maximum reuse of existing parts. PLM brings many benefits (Fig. 8.5). In the consumer electronics industry, the focus is on managing the BOM across the Extended Enterprise. Companies have to take account of fast-changing

50% faster product development	improved management of variants
greatly reduced data transfer time	improved collaboration with partners
reduced time to communicate changes	reduced document control costs
standardisation of processes across sites	increased outsourcing to low-cost suppliers

Fig. 8.4 Typical benefits of PLM in the automotive industry

reduced product development time	increased outsourcing
greatly reduced product change cycles	enhanced history tracking
improved document management	global access to product data

Fig. 8.5 Typical benefits of PLM in high-tech industries

global and local trends. There's an increasing need to meet environmental regulations and compliance requirements such as those resulting from the Restriction of Hazardous Substances (RoHS) and Waste Electrical and Electronic Equipment (WEEE) Directives introduced by the European Union. The RoHS regulations, for example, require electronics companies to provide proof that they have complied with regulations limiting the amount of six hazardous materials, including lead, in their products.

In industries such as industrial equipment, factory automation and heavy vehicle, reliability is important for customers. Products are often complex and engineered-to-order. Configuration Management is a key issue. Typical targets for PLM are change cycle reductions, reduced time to volume production, reduced rework costs and management of customer-specific products.

In the pharmaceutical industry, the focus is on discovering new compounds, and managing clinical trials. Idea Management is important, as is conformance with regulations. Typical targets for PLM include more new products, extended product lifecycles, reduced document control costs and improved product data visibility.

In the chemical industry, conformance with REACH, the EU regulatory framework for the Registration, Evaluation and Authorisation of Chemicals is needed. In the Nuclear Power industry, safety and security are all-important. Regulations depend on the country. In the US for example, regulations are set by the Nuclear Regulatory Commission. In the UK, it's the Nuclear Installations Inspectorate. The medical equipment industry needs to bring innovative products to market rapidly and demonstrate compliance with Food and Drug Administration (FDA) regulations requiring correctly controlled documents, drawings, and data management procedures. In the fashion industry, time-to-market, fast response to change, and collaborative working between designers in one country and factories in others are all important. Companies in the utility sector have to meet stringent environmental regulations. With many small subcontractors involved in developments, exchange of product data between different applications is a key issue.

Thus, although companies in different industries have similar objectives for PLM, the exact requirements may differ. PLM isn't "off-the-peg", "one size fits all". Functionality and implementation priorities depend on the specific market needs and objectives of each company.

8.2.2.3 Different Scope

The scope of a PLM Initiative may vary greatly from the Initiative of one company to that of another. In some cases, the PLM Initiative may address the entire PLM Grid (Fig. 1.5). In other cases, the Initiative will only address some parts of it, or perhaps just one part. In theory, it would always be best to address the entire Grid. However, in practice, there are often good reasons why this option isn't appropriate. For example, a company may not have the time, or the resources, or the need, to look at all areas. Or, it may already have looked at some areas. Or, it may be that top management wants to limit the description to a few clearly-defined areas.

8.2.2.4 Different Starting Points

The way forward will be different for different companies. They'll be approaching a PLM Initiative from different starting positions (Fig. 8.6). Some may already have experience of PLM, some may have none. As a result they'll have different questions about PLM.

A company looking at PLM for the first time may have many general questions (Fig. 8.7). More experienced companies may already have the answers to such questions.

A company that already has some experience with PLM may be creating a business case for PLM. It may have already answered initial questions about PLM. At this stage, it's likely to have more questions, including some very specific questions (Fig. 8.8).

A company at this stage, of creating a business case, could be looking for the best way to develop a justification of the PLM Initiative (Fig. 8.9).

Another company may be intending to evolve from departmental use of a PDM system to an enterprise-wide approach to PLM. Expecting to expand its range of activities, it's likely to have some specific questions about business processes and product data (Fig. 8.10).

Another company may be facing business drivers demanding much greater effectiveness and efficiency. It may have few questions about IS. Its questions are more likely to address business issues (Fig. 8.11).

As the next section shows, the objectives of the Initiative may be very different, and the resulting Initiatives may address very different topics.

looking at PLM for the first time	expanding an implementation from PDM to PLM
creating a PLM business case	responding to competitive pressures

Fig. 8.6 Different starting positions before a PLM initiative

what is PLM?
how and where should we start with PLM?
how can we improve chances for success with PLM?
what should our PLM concept include?
where does PLM fit with other initiatives in our company?
our CAD and ERP system vendors have different PLM concepts. Who's right?

Fig. 8.7 Initial questions about PLM

what should we include in the business case?	what figures are realistic?
how can we quantify the value of PLM?	how do we calculate ROI?

Fig. 8.8 Questions about a PLM business case

Phase	Type of Savings	Value of Cost Savings	Type of Gains	Value of Revenue Gains
Imagine	Cost reductions (manpower, fees)	Comparatively low	New products and services	Very High
Define	Cost reductions (project, manpower)	Comparatively low	Better products and services	High
Realise	Cost reductions (material, manpower)	Medium	Fast availability of customized products	High
Support/ Use	Cost reductions (material, manpower, warranties)	Medium	Upgraded/ extended products & services	Very High
Retire/ Recycle	Cost reductions (manpower, fines)	Medium	Material reuse	Medium

Fig. 8.9 Justification of a PLM initiative

what do we do next?	how should we build a data model for the lifecycle?
where can we gain the biggest benefit?	how do we handle multiple applications due to acquisitions?
how can we get our support costs under control?	how can we automate our business processes?

Fig. 8.10 Questions related to expansion from PDM to PLM

how can we produce more products faster?	how can we support products world-wide?
how can we compete against low-cost producers?	how can we identify more great products?

Fig. 8.11 Questions oriented to improved business performance

8.2.2.5 Different Objectives

The starting point for PLM should result from the objectives set by top management. These are likely to be business objectives addressing cost, quality and time (Fig. 8.12).

In addition to the business objectives, there may also be some operational objectives for the PLM Initiative. These may be at the departmental level (Fig. 8.13).

The reasons to implement PLM differ from one company to another, and depend on the particular position and objectives of the company. Many managers see cost reduction as an important reason for introducing PLM. There are many areas in which costs can be reduced (Fig. 8.14).

increase product revenues	reduce product cost
increase revenues of product-related services	increase product innovation
reduce costs	improve product quality
improve time to market	respond faster to changing markets

Fig. 8.12 Examples of business objectives for the PLM initiative

Fig. 8.13 Examples of operational objectives for the PLM initiative

optimise resources	improve product development efficiency
ensure compliance	improve service operations
automate document release	make it easier to find information
improve business processes	provide a single source of information
improve decision-taking	improve communication
support distributed teams	reduce the number of IS applications

Fig. 8.14 Potential sources of cost reduction with PLM

product development costs	personnel costs
direct material costs	inventory costs
warranty costs	production costs
prototyping costs	service costs
validation costs	Information System costs

Quality Improvement is also an important reason for managers thinking of introducing PLM. They look to PLM to improve quality in many activities (Fig. 8.15).

Time Reduction is another important reason for managers to introduce PLM. They may see opportunities throughout the product lifecycle, not just in product development (Fig. 8.16).

Business Process Improvement is an important reason for introducing PLM. In many companies, managers are looking at streamlining and harmonising processes. When companies reengineer processes they have the opportunity to identify the most effective way to work, remove waste activities and get Lean. The introduction of PLM provides an opportunity for them to define and implement the best product-related processes across the lifecycle.

Product innovation is becoming a prime concern for many companies. Increased competition means they have to develop better products and develop them faster.

improve conformance with customer requirements	reduce the number of returns
reduce product faults in the field	reduce the number of customer complaints
prevent recurring product problems	reduce errors, rework and wasted efforts
reduce manufacturing process defects	product data must be 100% correct

Fig. 8.15 Potential sources of quality improvement with PLM

Fig. 8.16 Potential sources of time savings with PLM

reduce time to market	reduce project times
reduce time to volume	reduce project overrun time
reduce time to value	reduce engineering change time
reduce time to profit	reduce cycle times

Executives are often frustrated by the low level of product and service innovation in their companies. They want managers to turn on new revenue streams and ramp faster. They want to get increased revenues sooner. They're looking for PLM to increase the innovation rate without compromising creativity or quality.

Compliance is a concern for companies faced with an increasing number of regulatory requirements. Managing voluminous and frequently-changing regulations for different products and services in different countries is a time-consuming task. PLM provides product developers and compliance specialists with rapid access to the right information. And it provides regulators the proof that their requirements have been met. The proof comes in the form of documents. The templates, results, process descriptions and workflows necessary to demonstrate compliance can all be managed in the PLM environment.

Mechatronic products contain mechanical, electrical, electronic and software modules. Companies usually develop mechanical, electrical and electronic components in a similar way, with similar processes and applications. However, in the past, the processes and applications used for software development have generally been very different. Using two separate sets of processes and applications creates all sorts of problems. It can lead, for example, to customers receiving control software that doesn't correspond to their product hardware. Managers look to PLM to provide a better way to manage mechatronic products.

Collaboration has become increasingly important in the early twenty-first century environment of networked and fragmented research, development and support. Web and collaborative technologies that support the PLM activity enable research and development to be carried out in a well-managed way in multiple locations. They enable product developers, sales people and service workers to interact with customers and partners on a global basis. They allow product development and support to occur on a 24/7 basis. Team members can be based anywhere yet work together in spite of space, time and organisational differences. They don't need to be co-located. PLM enables them to achieve use and re-use of common parts, worldwide engineering change management, and global information exchange, synchronisation and interoperability.

Intellectual Property Management is a concern for many companies. Product know-how is one of the most valuable resources in a company. It's an increasingly valuable resource for corporate growth, and must be kept secure. PLM provides the "Intellectual Property Vault" for protection of product know-how in the face of global competition and the potential risks from terrorism and economic espionage.

PLM is so pervasive in a company that it can also provide benefits in many other areas (Fig. 8.17).

improve business decisions	provide traceability
improve visibility over the supply chain	manage product portfolios
increase visibility into manufacturing operations	analyse product information across the lifecycle
improve risk management	provide feedback from each phase of the lifecycle
reduce engineering changes late in the lifecycle	enable better management of outsourced tasks
ensure compliance with standards and regulations	provide traceability

Fig. 8.17 Other potential improvement areas for PLM

8.3 Getting Started

Executives and middle managers are aware of PLM and the need to do something about it. They have many reasons for moving ahead with PLM (Fig. 8.18). They see opportunities in many areas, but it may not be easy to get started on the best path forward.

8.3.1 Middle Managers and Executives

Due to the enterprise-wide scope of PLM, it can be difficult for middle managers to start activities on PLM. They can see the potential for major benefits, but find it difficult to know where and how to achieve them. Middle managers are aware, from their everyday activities, of the need for PLM. However, it can be difficult for them to start a PLM Initiative. Usually they don't have the required authority or responsibility. In addition, they're often overloaded with other activities and projects that have higher priority and are already running. Frequently, the result is that they make little or no headway with PLM. This can have many negative effects (Fig. 8.19).

Due to the enterprise-wide scope of PLM, it's at the level of the VP (or business executive of similar rank and power) that action has to be taken if the expectations of PLM are to become reality. However, in the current highly competitive global environment, many business executives feel that they're already overloaded with responsibility and work. Perhaps they've been given additional responsibilities extending beyond their usual areas. For example, they may have been tasked with integrating newly acquired companies, or with overseeing operations in Brazil, India, Russia, South Africa or China. They may be involved in other projects, such as headcount reduction and the introduction of lean techniques. With little time

the product is at the heart of business strategy. PLM enables a quantum leap in product innovation
PLM can meld collaborative Web tools and enterprise apps in a push for market-leading products
PLM is the final strategic building block for the CIO's enterprise application architecture
PLM enables information automation and system integration with accurate and timely product data
PLM enables benefits for the 80% of the product-data consumer-base outside the R&D Department
PLM is the final plank of the Business Process Framework
PLM is a keystone activity of the Lean Enterprise
PLM is part of the foundations of the Extended Enterprise
PLM increases earnings, getting better products to market faster, extending lives of mature products

Fig. 8.18 Reasons for looking at PLM

decisions about next steps for PLM are delayed	problems arise with partners wanting to move ahead faster
achievements of PLM benefits is slow	frustration of product developers and product managers
the company falls behind competitors	PLM progress stalls

Fig. 8.19 Effects of making limited headway

available, they may not want to get involved with a subject such as PLM that can seem unclear in both scope and potential benefit.

Another reason that executives may not be convinced that they should invest time and effort in PLM is its enterprise-wide character. This may lead executives to look at PLM and decide that it doesn't lie in their particular domain of responsibility. A CIO may get the impression that PLM is mainly an issue for Product Managers and Product Development Managers. But Product Managers may see PLM as being mainly a question of applications, so lying in the IS area.

Another issue is that some experience-hardened business executives are sceptical of claims for new breakthrough approaches and technologies. They may see PLM as just one more breakthrough among the many that are touted. It may be difficult to convince them that it will bring success, and is worthy of their attention. Other executives may be looking for short-term improvements with impact on the financial figures in the next quarter. They're likely to consider that PLM doesn't fall in that category.

Another difficulty is that, in many organisations, there's not yet a corporate plan or funding for PLM. There's no PLM budget, and executives haven't been assigned to PLM, or set an annual target for PLM. As a result, none of the executives feel any responsibility for PLM.

8.3.2 Company Dilemma, Personal Dilemma

A dilemma arises in many companies as people see the need for, and opportunities of, PLM yet don't see the expected resulting action. On one hand, there's a feeling in the company that PLM should be implemented. On the other hand, due to various concerns, there's little progress with PLM (Fig. 8.20).

In this situation, with PLM looking strategic, but not being acted on by high-level executives, middle managers face a dilemma. Should they try to do something about PLM, or should they forget about PLM and carry on with "business as usual"?

If they do try to do something about PLM, they may well be seen later as having been instrumental in helping the company to achieve major benefits through PLM. They may enable the company to seize new opportunities and solve long-running problems. They'll stand out from timeservers and self-seekers. Of course, on the other hand, if they try to do something about PLM without support from above, they could expose themselves to criticism for not doing what they've been told to do. They could be blamed for not following the plan prepared by their boss. Even

business executives are already stretched with other tasks	headcount reduction has led to a lack of resources
there isn't a clear vision of PLM for people to aim at	PLM responsibility isn't defined
waiting for market improvement before starting new initiatives	the company is busy with other projects
PLM doesn't fall nicely into an individual department's scope	PLM may look too strategic and long-term

Fig. 8.20 Factors holding back PLM progress

there are already many projects running in the company
PLM isn't the only issue in today's global industrial environment
the company has slimmed down. There aren't enough people for a PLM project
few people have a broad enough overview to lead a PLM project
it's not clear who should be responsible for PLM
business executives are already stretched with other tasks
the CFO has put new initiatives on hold
middle managers are already stretched with other tasks
middle managers don't have the authority to launch company-wide PLM activities
people enjoy fire-fighting the present environment. Why rock the boat?
many people can't see the potential improvements with PLM

Fig. 8.21 An initial list of reasons justifying a lack of PLM action

worse, they could be accused of lowering morale and productivity by pointing out areas of weakness and making suggestions for change. Sometimes, not sure how to proceed, they start to make a list of reasons to justify why they don't need to do anything about PLM (Fig. 8.21).

Then they go back to work on everyday business. At the back of their mind, new entries for the list appear. After a while, they go back to the list, and add a few more reasons (Fig. 8.22).

Then they go back to work on everyday work. After a few weeks, they begin to think about PLM again, and find some more reasons for the list (Fig. 8.23).

Having made such a list, the manager realises that it might be better to try to do something about PLM. Otherwise, they could be accused of being negligent. Or of not offering the company the opportunity to make major gains with PLM. Of course, the manager may then think that PLM will come one day anyway, and for the moment it's probably not required, as top management hasn't asked for it. And of course, they can comfort themselves with the thought that there's no way they can do it on their own. So they might just as well wait until their boss tells them to do something about it. And of course, if they did try to do something about PLM, they would expose themselves to criticism for doing something that wasn't in their job description. So they may think that the best way forward is to get on with that small improvement project which was planned the previous year, even though it probably won't lead to significant results.

managers of projects that overlap with PLM will fight it. They want to keep their projects
PLM will be massive, but it's not clear exactly what it is, or what its scope will be
people talk of PLM in different contexts. This is confusing
people who don't know about PLM find it difficult to understand how it can help them
executives don't understand enough about products to see the need for change
the company is focused on short-term payback. PLM looks long-term for the CFO
PLM looks confusing and difficult to succeed with
without a dominant vendor driving the PLM market, it may be unwise to start with PLM

Fig. 8.22 More reasons to justify a lack of action

PLM isn't in the company's annual plan or budget	there's a lack of documented PLM Best Practice
a lack of methodologies for implementing PLM	the CIO is concerned about expensive integration

Fig. 8.23 Even more reasons to justify a lack of action

8.3.3 Going Nowhere

These dilemmas have arisen for many managers in many organisations. They lead to a repetitive situation, akin to going round in circles (Fig. 8.24).

8.3.4 Getting to the Start Line

Many companies face the Double Dilemma over PLM. On one hand, it's clear that PLM makes sense and that it's necessary. It's clear that PLM makes sense and that it's gaining in importance and acceptance. On the other hand, it's not clear what to do about it, how to do it, or who should take action.

However, it's clear that, at some stage, the person who will have to take action is a top-level executive with the authority and responsibility to address a subject that's enterprise-wide and addresses products, processes and applications. Someone who's responsible for ensuring the company improves business performance and makes money for shareholders.

It's clear that the top-level executive may not have the time to get deeply involved with PLM. However the executive can set up and sponsor a company-wide PLM Initiative under the leadership of a senior manager. It's also clear that the action will include the launch of a PLM Initiative, the development of a PLM Strategy and the deployment of PLM. And presumably it's clear that before the top-level executive can launch the Initiative, someone else will have to explain the case

in previous years, the company had many performance improvement projects, for example, to implement new application software, define business processes, and take on board Concurrent Engineering
in spite of all the past projects, there's a problem related to some of the company's products. There's a lot of discussion about how to solve it. The usual way to solve it would be to launch an improvement project
when middle level managers start looking at the details of the proposed improvement project, they see
many causes for the problem. And these involve several processes and several departments
they realise that what's needed is some kind of overall joined-up PLM approach that addresses the problem in a wider context of many applications, processes, and methods
they think about starting a project to develop an overall PLM Strategy
they look round the organisation for someone to lead such a project, but find that, after all the downsizing, offshoring and outsourcing, nobody has the time to do it
they look outside the company, and are quoted more than $50k by consultants for a PLM Strategy
they discuss if they really should spend $50k on a voluminous report, or if they should invest in licenses for a new application that will make everyday work easier
they decide to buy the new licenses and start the improvement project, even though they think it would be better to address the problem in a project with a wider scope
they continue to think about how to find the resources to develop a PLM Strategy
while thinking about this, some more product-related problems (such as lack of product innovation, product configuration errors, field failure reports being lost) occur, and get their attention
when they look at these problems, they see that these problems don't have a clearly-defined stand-alone scope, but involve several processes, several applications and several departments
this confirms the feeling that what's really needed is some kind of overall joined-up PLM approach
however, another review of availability shows there's nobody available to lead an initiative, and none of the business executives have been given the responsibility for PLM
they start some more small projects to address the latest product-related problems

Fig. 8.24 A repetitive situation for middle managers

PLM manages the product all the way across its lifecycle. (There's been nothing available to do this in a coherent way, and that's caused problems)
PLM provides visibility about what's happening to the product across the lifecycle. (It will be clear what's happening with products and projects)
PLM gets products under control across the lifecycle. (Which means that executives will be in control, face less risk and have more influence)
In the past, products were to a certain extent managed across the lifecycle, so a lot of the components needed for PLM already exist. (Which means that PLM doesn't involve starting from new, but building on what already exists)
The benefits of PLM are measurable and visible on the bottom line. (Typical targets for PLM are to increase product revenues by 30% and to decrease product maintenance costs by 50%)
PLM is holistic. (PLM doesn't just address one resource, and improve use of that resource while reducing the effectiveness of other resources)
There's currently not an off-the-shelf solution for PLM. (Which means that each company must define its own solution for PLM)
With PLM, one person will be responsible for all the products, which will be visible and under control. (Instead of having unclear multiple responsibilities)
The company should launch a PLM Initiative. (PLM enables the company's product-related objectives to be achieved)

Fig. 8.25 Potential contents of the presentation to the top-level executive

for PLM to them, very clearly and concisely, and in language they understand. And, presumably, knowing how things work in many companies, that explanation will be in the form of a PowerPoint presentation which will be prepared and presented by one or more people who report to that executive (Fig. 8.25). And the objective of the presentation will be to help the top-level executive take action.

The objective of the presentation isn't to explain all the details of PLM to the executive. It shouldn't be a long presentation. It could just include about 20 slides (Fig. 8.26), and take about an hour to present.

After initial discussions between middle managers, the possibility of making such a presentation can be discussed with a key executive. A draft presentation can be built. The subject can be discussed again with the executive, this time with the help of the slides. More feedback will help improve the presentation. Other people will be invited to join the discussion. Before long, the executive will be making the presentation to other executives, and the company will be on the way to PLM.

Discussing and creating a presentation doesn't take long. And the timeline for the above activities doesn't have to be long either (Fig. 8.27). Three months should be enough.

Fig. 8.26 Structure of the presentation to the top-level executive

Title of the presentation	1 slide
Contents of the presentation	1 slide
Objective of the presentation	1 slide
This is PLM	8 slides
PLM: our benefits and opportunities	4 slides
Three ways to move forward with PLM	3 slides
Ten step approach to PLM Launch	2 slides

Month 0	Meet with the executive
Month 0	Create draft presentation
Month 1	Show presentation to executive
Month 1	Improve the presentation
Month 1	Present the presentation again to the executive
Month 2	Discussions with other executives
Month 3	Define and launch the PLM Initiative

Fig. 8.27 Timeline for preparing to launch the PLM initiative

carry out a Feasibility Study	develop the PLM Implementation Strategy
understand the Current Situation	develop the PLM Implementation Plan
develop the Vision	build a Financial Justification
develop the PLM Strategy	develop the PLM Initiative Charter

Fig. 8.28 Frequent steps in a PLM initiative

8.4 Approaches to a PLM Initiative

8.4.1 Standard Approach

Some clearly-defined steps are frequently found in PLM Initiatives (Fig. 8.28). However, many companies take a pick-and-mix approach to these steps. The resulting activity often depends on what they've already achieved.

The resulting Initiatives are all multi-step but the details are different in different companies (Fig. 8.29).

8.4.1.1 Standard Approach, Different Steps

With so many differences between the needs and situations in different companies, it's not surprising that the steps taken in the resulting PLM Initiatives will be very different (Fig. 8.30).

For a truly enterprise-wide PLM Initiative, the first step may be to develop and communicate a Vision of the proposed new environment, including a future PLM Strategy, so that everyone knows where they're going. The step after that could be

Path 1	*Path 2*	*Path 3*
Launch the PLM Initiative	Launch the PLM Initiative	Carry out a PLM Audit
Understand the Objectives of PLM	Carry out a Feasibility Study	Review PLM Vision/Strategy
Understand the Current Situation	Understand the Current Situation	Review Audit Results
Understand the Principles of PLM Strategy	Develop the PLM Strategy	Review Implementation Strategy
Understand the Future Situation	Develop the Implementation Strategy	Adjust the Implementation Plan
Develop the PLM Strategy	Develop the PLM Implementation Plan	Implement the Plan
Develop the PLM Implementation Strategy	Implement the Plan	
Develop the PLM Implementation Plan		
Implement the Plan		

Fig. 8.29 Different paths to implementation

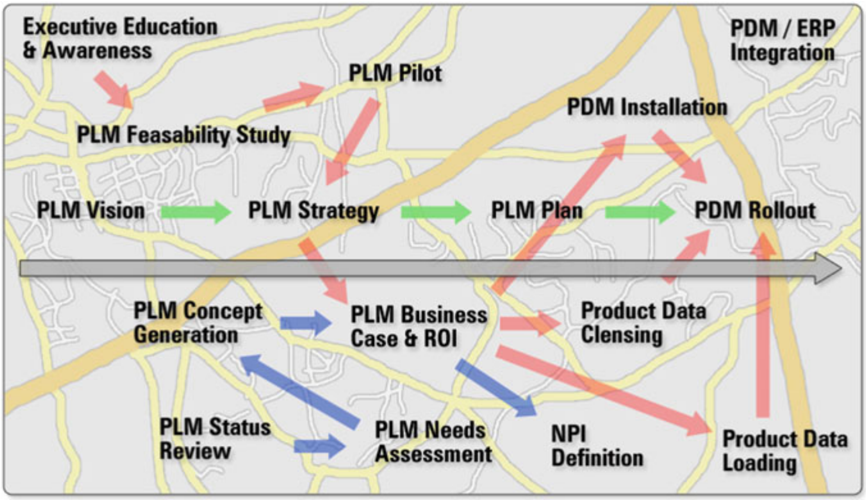


Fig. 8.30 Different steps in different companies

to define an Implementation Strategy to achieve the PLM Vision. Then an Implementation Plan could be developed. Once the plan has been implemented, the benefits can be harvested.

At the other extreme, a company's approach to PLM may be limited to departmental cherry-picking. In this case, the Vision, and even the Strategies, may not be needed. In all cases though, a plan will be needed to show what has to happen, when it should happen, and who does what to make it happen.

8.4.1.2 Getting Alignment of Views

Before getting to the main steps, a frequent activity is to get alignment on a common view of PLM. At the beginning of the Initiative, people in the company may have very different views of PLM (Fig. 8.31).

it's about managing products across their lifecycles, but I don't know how you do it
it's an information strategy
it's about reducing time to market
it's to improve innovation, we had it in my previous company
it's to manage our CAD data, so first we need to select a PDM system
it's like Configuration Management, forget it, we already do it
it's about producing and supporting our products better
it's a project to implement a single database worldwide
I've heard a lot about PLM but, to be honest, I don't know what it's about
I've read blogs about PLM and am totally confused

Fig. 8.31 Differing views among initiative team members

we need to get IS involved upfront so we fit their architecture	we need to hire a good consultant
we'll start by selecting a PDM system, and take it from there	first we'll define a data model
we need the business to define its requirements	we already have PLM
we start with a process landscape	let's start with a Feasibility Study

Fig. 8.32 Differing views on getting started with the PLM initiative

Not only may Team members have different views of PLM, they will probably also have different views on how to get started with the Initiative (Fig. 8.32).

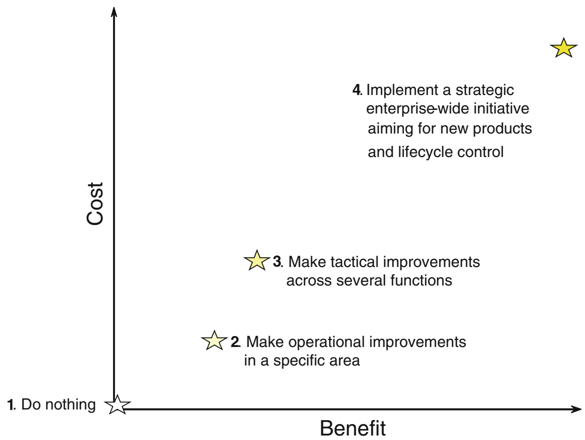
8.4.1.3 Feasibility Study

The range of possible PLM Initiatives is very wide. The PLM Initiative of a particular company may fall anywhere in the range between "supremely strategic" and "totally tactical". For a company with little knowledge or experience of PLM, a feasibility study can be a good way to find out what type of approach, and what level of response, is appropriate. Figure 8.33 shows four options that can be examined in the Feasibility Study.

Different options have different costs and different benefits. Examining different options will make it clear to everybody concerned what the PLM Initiative is going to address, what it's likely to cost, and what it's expected to achieve. It's important to make clear to everybody concerned just what the PLM Initiative is expected to achieve. The results of different approaches are very different. There's a danger that people will expect strategic results from a tactical approach and a tactical investment. Major gains come from long-term strategic approaches, not from short-term tactical projects. However, this goes against the philosophies of "getting something for nothing" and "getting something for nothing, fast".

In the Feasibility Study, the activities for each of the four options are similar (Fig. 8.34).

Fig. 8.33 From totally tactical to supremely strategic



document the objectives and the scope of the option
identify the benefits of achieving the objectives, and estimate their financial value
identify the activities and effort required to achieve the objectives, and estimate their cost
create the business case
create an outline plan for implementation of the activities identified

Fig. 8.34 Activities for each option

Feasibility Study : Options for our PLM Activity

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1. Executive Summary and Recommendations

2 Introduction
2.1 Background to the Study
2.2 Approach for the Study

3 Current Situation
3.1 Business Objectives
3.2 Current PLM Activity

4 Description of the Options
4.1 Option A Do Nothing
4.2 Option B Departmental Improvements
4.3 Option C Cross-functional approach
4.4 Option D Strategic enterprise-wide initiative

5 SWOT Analysis

6 Conclusions and Proposed Next Steps

Appendix Detailed Information

Fig. 8.35 Contents of a feasibility study report

better understand the product lifecycle	manage product development projects better
better understand activities across the lifecycle	define the roles in the product lifecycle
use a PLM phase/gate methodology across the lifecycle	define end-of-life needs
position and quantify each product in the lifecycle	define product grouping
train people to work effectively in a lifecycle environment	use a PDM system across the lifecycle
maintain and reuse product development knowledge	define information needs across the lifecycle

Fig. 8.36 Actions identified in a feasibility study

The Feasibility Study should lead to the selection of one of the Options. The results of the Feasibility Study should be documented in a Feasibility Study report (Fig. 8.35).

The Feasibility Study may lead to identification of the need for some specific actions (Fig. 8.36).

8.4.1.4 The Current Situation: Steps and Structure

A very good understanding of the activities and the resources in the product lifecycle is an important component of a PLM Initiative. This understanding must be based on factual information, not on guesses and opinions. If you don't know the current situation, you may be missing key information that you need before making your proposal for the future situation. If you don't know what you have, or what the problems are, it's going to be difficult to know what you're going to improve, or fix, and why. There are probably things you need to remove before you add new things. There could be many things that work very well. You may not want to change them, because changing them might impair performance, not improve it. If you don't know the current situation, you may miss easy improvement opportunities. If you know what you do badly, you can make sure you don't do it again in the future, and don't propose the same wrong things for the future. And, to successfully implement change, you need to communicate it to, and convince, many people. You need to communicate a clear documented message. If you can't even explain how things are today, it's unlikely that anyone's going to believe your suggestions for the future.

Understanding and documenting the Current Situation is a 14-step activity (Fig. 8.37).

Figure 8.38 shows some of the methods that may be used in the activity of describing the current situation.

Two documents should result from the activity of describing the current situation, the Current Situation Report and a PowerPoint presentation. One of the dangers when describing the current situation is that important information can be drowned by the huge amount of data that's collected. As a result, it's useful to define the shape of the report before starting to collect data (Fig. 8.39). The main findings about the current situation should also be documented in a PowerPoint presentation that the Initiative Leader can present to top management.

Fig. 8.37 14 steps to understand and document the current situation

1. Start the Current Situation activity

2. Confirm the objectives
3. Confirm the scope
4. Clarify the reporting requirements
5. Clarify the methods to be used
6. Provide training if required
7. Identify the information needed to document the Current Situation
8. Develop the approach to get this information
9. Create the report structure

10. Get the required information
11. Review the information
12. Write the report
13. Finalise the report
14. Present the report

surveying lifecycle participants	holding meetings of study groups
carrying out interviews	reviewing documentation
documenting real-life examples	modelling and mapping

Fig. 8.38 Activities when describing the current situation

Fig. 8.39 Example of the content of the current situation report

The Current Situation Report

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Section 2 Methods
Section 3 High-level Findings
Section 4 Details for each Component
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8.4.1.5 A PLM Vision: Steps and Structure

A PLM Vision represents the best possible forecast of the desired future PLM situation and activities. It outlines the framework and major characteristics of the future activities. For some companies, one step in the Initiative will be to develop and communicate a PLM Vision for the future environment (Fig. 8.40). They'll do this to find out where they're going in the future, and to help everyone share this understanding.

One of the risks when describing the future situation is that people will describe what they understand, and what interests them, but not what's wanted. Describing what they, personally, want is relatively easy. However, it can be a daunting task to describe what others may want, but don't communicate, and perhaps can't even be imagined. To help keep on track, it's useful to define three targets in advance (Fig. 8.41).

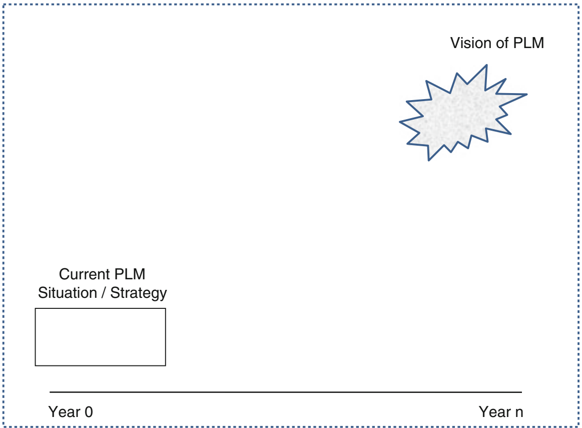

Fig. 8.40 PLM vision

Fig. 8.41 Three targets to define in advance

the approach for describing the future situation
the information that will be needed
the deliverables that will be produced

Defining the deliverables up-front will help define the approach. They will depend on the scope of the project. As the scope is likely to differ from one company to another, the deliverables are also likely to differ. However, there are some common deliverables (Fig. 8.42) that we've seen in many projects.

Development and maintenance of the PLM Vision is a 16-step activity (Fig. 8.43).

Figure 8.44 shows the typical structure and content of a PLM Vision report. A report like this will help people throughout the company to understand the targeted future PLM environment.

8.4.1.6 The Future PLM Strategy: Steps and Structure

The future PLM Strategy describes how PLM resources will be organised, managed and used to achieve the objectives (Fig. 8.45).

a description of the scope and the objectives	a list of expected benefits
a brief overview of the scenarios created and investigated	a business case model of the future situation
a brief overview of the expected overall future situation	some KPIs and their target values

Fig. 8.42 Frequently encountered visioning deliverables

1. Start the Visioning activity

2. Clarify the objectives
3. Identify the factors to be addressed
4. Identify the questions to be answered
5. Get information to answer the questions
6. Develop some drafts of the Vision (scenarios)
7. Document the scenarios
8. Test the scenarios to see if they answer the questions and meet the objectives

9. Unless there are at least three reasonable scenarios, return to Step 3
10. Carry out SWOT analysis on the reasonable scenarios

11. Identify the preferred scenario
12. Add the strengths of the other scenarios to the preferred scenario

13. Test the scenario to see if it answers all the questions and meets the objectives
14. If there are doubts about the scenario, return to Step 3

15. Document the Vision that answers all the questions and meets the objectives

16. Maintain the Vision

Fig. 8.43 16 steps to develop and maintain the PLM vision

Fig. 8.44 Example of the content of the PLM vision report

Title : The PLM Vision Report

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2.3 Key issues : markets, customers and competitors
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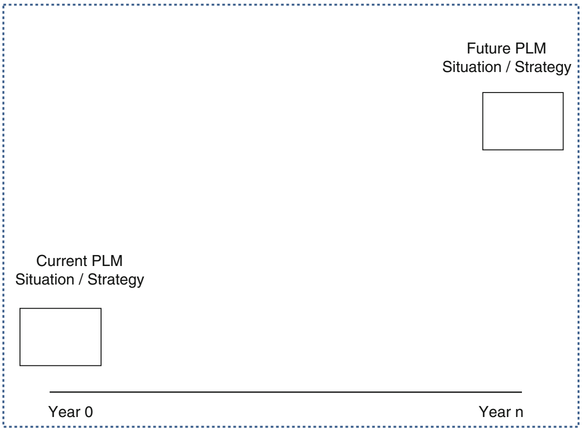

Fig. 8.45 Current and future PLM strategies

Developing the future PLM Strategy is a 9-step activity (Fig. 8.46).

It's useful to define the shape of the PLM Strategy Report before starting to develop the Strategy. Team members will then be aware of what they have to achieve. Figure 8.47 shows the typical content of the PLM Strategy report.

Fig. 8.46 9 steps to develop and communicate the future PLM strategy

1. Start the activity to develop the PLM Strategy

2. Clarify the reporting requirements
3. Create the report structure
4. Gather information about the Future Situation
5. Develop Candidate Strategies (scenarios)
6. Select the Preferred Strategy

7. Finalise the report
8. Present the report

9. Communicate the Strategy

8.4.1.7 Financial Justification of the PLM Initiative

Every year, companies have the opportunity to invest in a variety of new and on-going short-term and long-term projects. These could include projects to introduce new products, improve manufacturing productivity, develop the corporate image, improve working conditions, improve processes and implement new applications. Someone, somewhere, has to select the most suitable projects for a company.

Top management has a difficult task in choosing which projects to fund. Most of the projects will appear very important. They will often involve a large initial investment, have a major effect on the company in the long-term, and have the potential for creating major upheavals. Top management is unlikely to understand the projects in detail, so will be heavily influenced by the people proposing projects, and the written proposals.

When a PLM Initiative proposal is presented to management, it should contain a financial justification that shows the required investment and running costs, the expected benefits, the expected return, the risks associated with the investment, and the effect of the investment on other areas of the company. Without such a justification, top management will be unable to decide either if the project is worthwhile, or if it's a better choice for investment than other projects.

Two types of benefit can result from the PLM Initiative, those that result in increased revenues and those that result in a reduction in costs. There are many ways in which PLM can increase revenues (Fig. 8.48).

A reduction in costs is another potential benefit of PLM. This can be achieved in many ways across the product lifecycle (Fig. 8.49).

A PLM Initiative will have associated investment and running costs. Figure 8.50 shows some typical initial costs.

Figure 8.51 shows typical costs after the initial investment. These are likely to be incurred over several years.

8.4.1.8 The PLM Implementation Strategy

The PLM Implementation Strategy shows how resources and activities will be organised to achieve the future PLM Strategy. It shows the activities that have to be

Title : The PLM Strategy Report

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Future situation of PLM activities and resources
Brief description of the selected PLM strategy
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o response to opportunities and threats
o fit to company strategy
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b. portfolio
c. customers
d. activities, processes
e. facilities
f. human resources
g. technology
h. practices
i. information
j. information systems
k. standards
l. relationships with other activities
m. interfaces
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Section 5 - Change strategy
Section 6 - Outline strategy implementation plan
major projects: objectives timing, resources, costs, benefits
project dependencies, priorities, organisation
Section 7 - Outline first year operating plan
Appendix 1 Detailed information about the Future Situation
Appendix 2 Detailed information about Strategy development and selection

Fig. 8.47 Example of the contents of the PLM strategy report

carried out to get from the current use of PLM resources to the future use of PLM resources.

The PLM Implementation Strategy is likely to be very different in different companies. Their current situation is different, their future situation is different. The scope of activities considered is likely to be different. And there are many ways to get from the current situation to the future situation. So, it's to be expected that each company will create a different Implementation Strategy.

increase the number of customers. For example, by reducing the overhead activity of product developers, PLM allows them to develop products for new customers
increase the product price paid by customers. For example, by increasing product quality, PLM enables customers to be charged increased prices
increase the range of products that customers can buy. For example, by improving product structure management, PLM enables more customer-specific variants
increase the number of products of a particular type that a customer buys. For example, by increasing product quality, PLM allows customers to dispense with second sourcing
increase the percentage of customers re-ordering. For example, by increasing product and service quality
increase the frequency with which customers buy. For example, by getting products to market faster and more frequently
increase the service price paid by customers. For example, by using PLM to improve the quality of existing services
increase the range of services that customers buy. For example, by using PLM to support additional services
get customers to pay sooner. For example, by developing and delivering products faster

Fig. 8.48 Some ways in which PLM can increase revenues

reduce the number of product developers	reduce the cost of holding products
reduce the number of support staff	reduce the cost of storing information
reduce the cost of materials used in products	reduce warranty costs
reduce the cost of quality	reduce penalty costs
reduce energy consumption	reduce rework costs
reduce finished stocks and work in progress	reduce documentation costs

Fig. 8.49 Benefits that result in a reduction in costs

initial investment in PLM applications (software)	initial investment in communications software
initial investment in complementary software	awareness training and education
initial investment in hardware for PLM applications	consultancy costs
initial investment in communications hardware	system selection costs

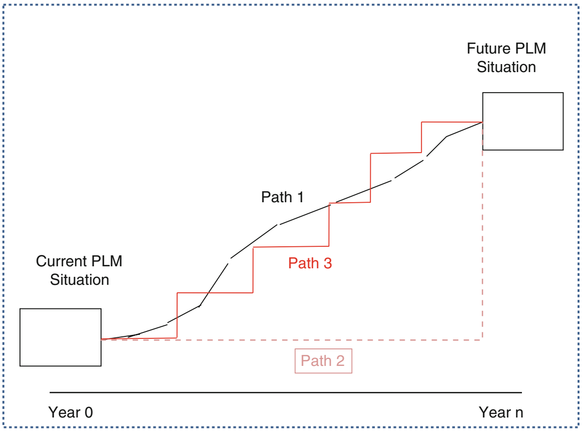
Fig. 8.50 Typical initial costs

further investment in PLM applications (software)	PLM application (software) maintenance costs
further investment in complementary software	complementary software maintenance costs
further investment in PLM application hardware	further investment in communications hardware
further investment in communications software	communication charges
costs for customising PLM applications	loading data in PLM applications
PLM application management and operations	cleaning product data
development of new working procedures	development of interfaces
on-going training and education	modification of existing procedures
participation in conferences and user groups	on-going consultancy

Fig. 8.51 Typical sources of costs after the initial investment

Figure 8.52 illustrates three of the many potential PLM Implementation Strategies (Path 1, Path 2, Path 3) for a particular company. Path 2 shows an implementation strategy of the "Big Bang" type, with everything changing in Year n. Path 1 shows an implementation strategy of the "Continuous Improvement" type, with many changes being made one after the other. Path 3 shows a phased approach with a small set of changes being introduced in each phase.

Fig. 8.52 PLM implementation strategy



Developing the PLM Implementation Strategy and Plan is a 10-step activity (Fig. 8.53).

It's useful to define the structure and shape of the report before starting to develop the Strategy (Fig. 8.54). Team members will then be aware of what they have to achieve.

The PLM Implementation Strategy defines the activities that have to be carried out to get from the current use of PLM resources in a company to the future use of PLM resources. To be able to develop the Implementation Strategy, it's necessary to have a basic understanding of both the current situation and the future situation in the company. For example, the description of the future situation may call for a single PDM system, but there may be multiple PDM systems in the current situation. There may not be an obsolescence process in the current situation, but an obsolescence process may be required in the future situation. The gaps should be listed and described in a Gap Description Matrix (Fig. 8.55).

1. Start the activity to develop the PLM Implementation Strategy

2. Clarify the reporting requirements
3. Create the report structure
4. Gather information about the Current Situation and the Future Situation
5. Understand the factors that may influence timing and priorities

6. Develop Candidate PLM Implementation Strategies (scenarios)
7. Select the Preferred PLM Implementation Strategy

8. Detail the PLM Implementation Plan

9. Finalise the report
10. Present the report

Fig. 8.53 10 steps to develop the PLM implementation strategy

The PLM Implementation Strategy Report

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Section 2 The Scenarios examined and analysed
Section 3 The selected PLM Implementation Strategy
Section 4 The proposed PLM Implementation Plan
Section 5 Next Steps

Appendix 1 Additional Details

Fig. 8.54 Typical content of the PLM implementation strategy report

Resource	*Gap Name*	*Current Situation*	*Future Situation*
Processes			
	Product Idea	No process	Single company-wide process
	Obsolescence	No process	Single company-wide process
Data			
	Product Numbering	Multiple numbering systems	Single company-wide system
Applications			
	PDM system	3 PDM systems used	Single company-wide system

Fig. 8.55 Excerpt from a gap description matrix

With the gaps between the current and future situations identified, it's time to look for ways to close them. Several ways should be proposed to eliminate each gap. They should be described in a Gap Elimination Matrix (Fig. 8.56).

The PLM Implementation Strategy will show how to get from the current use of PLM resources to the future use of PLM resources. There are many ways to do this, and the likelihood of finding the most appropriate at the first attempt is low. Several potential scenarios should be identified and documented. Each scenario will show a different way to reach the future situation. Each scenario should be described in detail. After the scenarios have been identified and described, they should be

Gap Name	*Potential Gap Elimination Approaches*
Product Idea	develop the process based on currently perceived needs
	develop the process with the help of Business Process Management consultants
	use the process proposed by the vendor of whichever application will be used
	use the best of the current in-house approaches
	purchase a new best-in-class application
	add customised functionality to the current PDM system
	add customised functionality to the current ERP application

Fig. 8.56 Excerpt from a gap elimination matrix

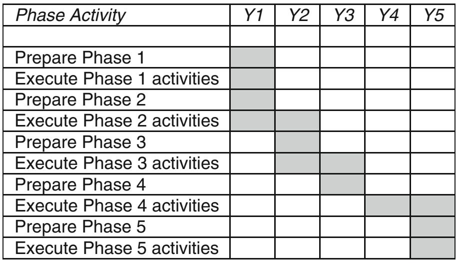


Fig. 8.57 Timing of phases

analysed. The strengths and weaknesses of each scenario should be described. Analysis of the scenarios leads to identification of the preferred PLM Implementation Strategy. This should be documented in detail and described in the report.

8.4.1.9 The PLM Implementation Plan

Each company will create an Implementation Plan built up of manageable and prioritised sub-projects. The PLM Implementation Plan should show how the overall vision will be achieved over the Initiative timeline. It should address the long term and the short term. For the long term, it provides management with the information necessary to understand activities, resources and timelines. The more specific the plan, the better. It should define an overall implementation timetable. It should show how the PLM implementation will be split into manageable phases. There should also be a more detailed plan for the first year.

Other views of the plan will show more details of the activities. They'll be needed for people who participate in, and manage, the activities. Different views of the Plan will be needed, with different levels of detail. One view could be a block diagram showing in which years each Phase will take place (Fig. 8.57).

The short-term plan should show management which actions need to be taken initially (Fig. 8.58). It should show achievement of benefits. The plan is more likely to be accepted if it includes some actions that will lead to short-term savings and other short-term benefits.

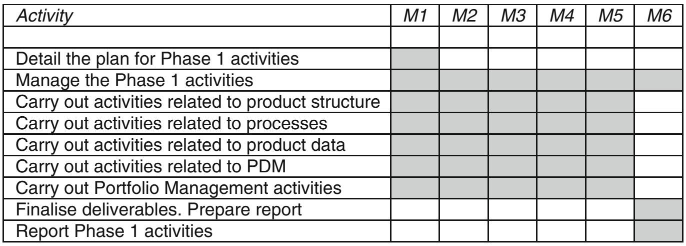


Fig. 8.58 Lower-level, more-detailed implementation plan

PLM Initiative Charter	
Table of Contents	
1 Introduction	6 Duration of the Initiative
1.1 Purpose of this Initiative Charter	6.1 PLM Roadmap and Major Milestones
	6.2 Timeline
2 Executive Overview of the Initiative	6.3 Plan and Schedule for Year 1
3 Justification for the Initiative	7 Budget for the Initiative
3.1 Business Objectives	7.1 Estimate
3.2 Business Impact	7.2 Funding
3.3 Strategic Positioning	7.3 Budget for Year 1
4 Scope of the Initiative	8 Organisation of the Initiative
4.1 Objectives	8.1 Roles and Responsibilities
4.2 Business Requirements	8.2 Stakeholders (Internal and External)
4.3 Major Deliverables	
4.4 Boundaries	9 Approval of the Initiative Charter
5. Assumptions and Risks	10 Appendices
5.1 Assumptions	A Referenced Documents
5.2 Risks	B Glossary
5.3 Dependencies	

Fig. 8.59 Example of the contents of the PLM initiative charter

8.4.1.10 The PLM Initiative Charter

The Initiative Charter is a document describing and authorising the Initiative. It outlines the reason and objectives for the Initiative, its cost and benefits, and the resources involved (Fig. 8.59). Depending on the company, it may range in length from a few paragraphs to more than one hundred pages. Some companies don't create an Initiative Charter, but include its contents in other documents.

8.4.2 The Ten Step Approach

The multi-step approach described in the previous section is likely to take many months. Another approach to starting the PLM Initiative is to take the Ten Step Approach. It's based on our experience of working with companies in many industry sectors. Its aims correspond to those of many of these companies (Fig. 8.60).

Based on these needs, we developed the ten steps of the approach (Fig. 8.61). Experience shows that these ten steps help in understanding how PLM can be applied to a business most effectively, and in getting executive approval for the PLM initiative to proceed.

The approach has been used in many companies, at different stages of PLM progress, in many industries. It's been found that the ten steps make it clear to everyone involved what has to be done. In a medium-sized company, a typical

Fig. 8.60 Aims of the ten step approach

build a business case for PLM and get management buy-in to proceed
uncover hidden needs and opportunities for PLM beyond the obvious
identify the best PLM approach aligned with business objectives
clarify the scope of PLM
gain clearer understanding of the ROI potential of PLM
define and prioritise a clear PLM Roadmap
implement PLM quickly and cost effectively, avoiding pitfalls
improve overall PLM success

Fig. 8.61 The ten steps of the ten step approach

1	PLM Status Review, Data Gathering
2	Executive PLM Education and Awareness
3	Best Practice Positioning
4	PLM Concept Generation and Analysis
5	PLM Scope Definition; Strategy and Roadmap Generation
6	Business Benefits and Business Case Development
7	ROI Calculation
8	Management Report Preparation
9	Executive Presentation
10	Executive Decision Support

project will run 6 weeks (Fig. 8.62), a very cost-effective 6 weeks compared to the months or more of time taken with the multi-step, pick and mix approach.

Clearly-defined deliverables for each step help show how the project will proceed, and make sure that key findings and proposals are captured and retained (Fig. 8.63). For example, the deliverable from the "PLM Status Review, Data Gathering" step includes an overview of the current situation. Much of this will be in the form of text, but it will also include numerous tables, lists and graphics such as histograms, pie charts and radar charts to help visualise why certain recommendations are warranted.

	Step	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6
1	PLM Status Review; Data Gathering	■	■				
2	Executive PLM Education and Awareness	■	■			■	■
3	Best Practice Positioning		■	■			
4	PLM Concept Generation and Analysis	■	■	■			
5	PLM Scope Definition; Roadmap and Plan Generation		■	■			
6	Business Benefits & Business Case Development		■	■			
7	ROI Calculation			■			
8	Management Report Preparation				■		
9	Executive Presentation					■	
10	Executive Decision Support						■

Fig. 8.62 The ten steps planned over 6 weeks

Step	*Main Deliverable*
PLM Status Review, Data Gathering	A report on the as-is situation, and expectations for the to-be situation
Executive PLM Education and Awareness	A PowerPoint presentation addressing potential benefits and opportunities of PLM
Best Practice Positioning	Improvement opportunities, strengths and weaknesses
PLM Concept Generation and Analysis	A report on potential PLM concepts, and reasons for the choice of a particular concept
PLM Scope Definition; Roadmap and Plan Generation	PLM Scope; PLM Roadmap; Plans
Business Benefits & Business Case Development	A report on expected costs, benefits, value and ROI
ROI Calculation	A realistic calculation of Return on Investment
Management Report Preparation	A Management Report and a presentation
Executive Presentation	Full understanding of the PLM proposal
Executive Decision Support	A Go/No Go decision

Fig. 8.63 The deliverables from each of the ten steps

Activity	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Clarify PLM Vision, including future PLM Strategy	■	■	■	■				
Detail the Current Situation	■	■	■	■				
Detail the Future Situation				■	■	■		
Develop the Implementation Strategy				■	■	■		
Revisit the Roadmap						■		
Describe the Next Steps						■	■	
Develop the Plan for the Next Steps							■	■
Report the Progress								■

Fig. 8.64 The plan for next steps

The deliverables from the "PLM Concept Generation and Analysis" step include, for each concept or option: a description; the benefits; the strengths and weaknesses; other issues; main activities; elapsed time; manpower requirements; costs; risks.

The plans generated in Step 5 of the Ten Step Approach include a detailed plan for the next steps. In addition to the planned activities, this will also show deliverables, participants and responsibilities (Fig. 8.64).

The deliverables from the "Management Report Preparation" step are a comprehensive report and an accompanying PowerPoint presentation that can be presented to executives.

8.4.3 After Initiative Launch

The end result of both the multi-step, pick and mix approach and the Ten Step Approach includes a Go/NoGo decision about the PLM Initiative from top management. In the case of a Go decision, the details of the required activities will have

Fig. 8.65 Progress towards targets

	Target	*To Date*
Rate of introduction of new products	+100%	+25%
Revenues from extended product life	+25%	+4%
Part reuse factor	7	2.2
Costs due to recalls, failures, liabilities	-75%	-5%
Development time for new products	-50%	-5%
Cost of materials and energy	-25%	-4%
Product recyclability	90%	12%
Product traceability	100%	22%
Lifecycle control	100%	14%
Lifecycle visibility	100%	18%
Revenues from new services on existing products	+40%	0%

been detailed in the Implementation Plan. Some of these activities have already been described in the previous sections. Among those that have not are Initiative Progress Reporting and the PLM Status Review.

8.4.3.1 Initiative Progress Reporting

With so much to do in a PLM Initiative, PLM team members sometimes forget its objectives. They concentrate so much on short-term tasks, requiring completion in a few days or weeks, that the overall objectives disappear over the horizon. However, the sponsors of the Initiative are not so interested in the results of day-to-day tasks. They want to see progress towards the targeted objectives. To keep stakeholders informed, the team should develop and apply procedures to capture, at regular intervals, the data from which such information can be prepared (Fig. 8.65).

8.4.3.2 Waning Interest and Pre-emptive Action

It's not unusual that, as time passes, people become less interested in the PLM Initiative. They look for a fresh and exciting new subject. They will be blind to any defects in their new project, yet anything that goes wrong in the PLM Initiative will get magnified out of proportion. This waning of interest can lead to serious effects (Fig. 8.66). In extreme cases it can lead to the Initiative grinding to a halt (Fig. 8.67).

Steering Committee stops steering	users complain about the software
top management loses interest	users complain about project management
middle management gets defensive	service providers don't take responsibility
users complain about bureaucracy	the Initiative Team is left with all the problems

Fig. 8.66 Effects of waning interest in the PLM initiative

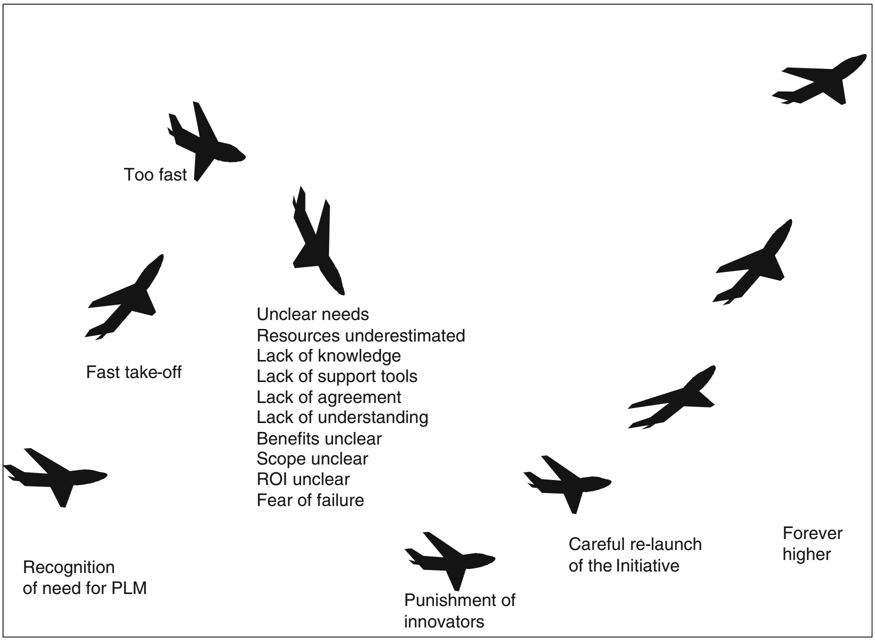


Fig. 8.67 Extreme effect of difficulties in the initiative

To make sure that this situation doesn't arise, the Initiative team needs to take pre-emptive action (Fig. 8.68). On one hand, it needs to prevent disaster occurring. And, on the other hand, it needs to take the time to communicate success.

8.4.3.3 PLM Status Review

Occasionally, for example every 9 months, there should be a formal review of the progress that the initiative is making towards meeting the targets. The review should lead to a detailed progress report. Deviations from plans should be noted and explained. Proposals for changes to plans should be documented and discussed with management.

Such a regular review shouldn't be seen as a criticism of the Initiative team, which is probably doing a great job and making a lot of progress. Instead, it should

set realistic objectives for the Initiative	prevent scope creep
develop a realistic plan and schedule	prevent requirements creep
take a rolling plan approach	be realistic about service provider involvement
include project buffer time	document all changes to Initiative plans and schedules
involve management in the Initiative	get all changes agreed by the Steering Committee
involve users in the Initiative	tell the Steering Committee about successes

Fig. 8.68 Pre-emptive action

Is the Initiative scope clearly defined? Has any scope creep been reflected in the plan?
Were expected benefits identified at the start of the Initiative? Has progress to benefits been measured and reported?
Is there a plan showing current activities, and their objectives, resources, deliverables and reports? Is the plan up to date and realistic?
Is time worked on the Initiative recorded correctly?
Are the objectives, deliverables and reports clearly defined and documented?
Are requirements well documented? Is there a tracking system for requirements and changes to requirements?
Are costs being tracked properly? Have cost variations been measured and reported?
Is there a Quality plan in place? Are there Quality checkpoints? Has there been an independent Quality review?
Are there enough resources on the team? Are team members working full-time on the Initiative? Does the Initiative team have the right tools and skills?
Are roles and responsibilities clearly defined? Do they correspond to reality?
Is there a training plan? Have team members been trained?
Is there a change strategy in place? Has communication been extensive? Have changes to reward systems been addressed?
Have all key stakeholders been identified and involved in developing the plan?
Are external partners being used? Are there contracts to retain key external partners?
Is there an up to date risk management plan? Are regular risk reviews undertaken?
Is there an issue escalation process? Are there contingency plans?
Is the business providing the necessary level of support? Is there sufficient executive support for the Initiative?
Is there effective sponsorship? Is there an effective guiding group?
Are Initiative documents well organised? Are they under version control? Are they well - structured and understandable?
Are there agendas for meetings? Are there meeting minutes?

Fig. 8.69 Some questions for a PLM status review

be seen as a way of stepping back from everyday tasks, and an opportunity to look again at the big picture. The resulting report should help with planning and moving forward.

The scope of the review may include questions on many subjects (Fig. 8.69).

There are several reasons for asking these questions (Fig. 8.70). One advantage of a regular review is that it keeps the focus on business benefits. Unless the focus is maintained on the expected benefits of a PLM Initiative, it's unlikely that they'll be achieved. There are always many opportunities for a PLM Initiative to drift off on a different tack that will take it far from the targeted destination.

Another advantage of a regular review is that it helps keep PLM on management radar screens. It's only too easy for management to agree to a large investment in PLM, and then, faced with everyday fire-fighting activities in other parts of the company, forget about the PLM Initiative, assuming subconsciously that it's making good progress.

It's often helpful to get an external expert to carry out the review (Fig. 8.71).

In many cases, the review will show that the Initiative is on the right track, and making good progress. It may also show that a few improvements and adjustments may need to be made.

identify and quantify progress towards targets	get a feel for any slippage between plans and reality
communicate progress towards targets	in the event of problems, put the Initiative on the right path

Fig. 8.70 Reasons for a PLM status review

an independent assessment of project progress	high level of acceptance of results by management
an opportunity to communicate progress	an opportunity to focus again on project objectives
expert advice concerning the project's next steps	support and communication of next steps

Fig. 8.71 Advantages of a PLM status review by an external expert

leave things as they are, hop ing the team will be able to put things right with some help from management
allow the Initiative to continue, but with a new Initiative leader
restart the Initiative with a new leader and/or a new team

Fig. 8.72 Future options for the initiative

However, in some cases, the review may show that the Initiative isn't making good progress. In such cases, it will probably be necessary to take a major decision about its future course. There'll probably be various options (Fig. 8.72).

The first option is unlikely to work. First of all, management probably doesn't have the time to provide the required support. And, without more management involvement, it's unlikely that the team is suddenly going to change its behaviour and act differently. The second option may work, but it's rarely the case that a PLM Initiative only goes off course because of its leader. The third option will lead to another failure unless a lot of work is also done to identify the causes of failure. Usually these are related to corporate and departmental culture. Unless they're identified and resolved, they'll still be there to cause failure for the new team.

8.5 Learning from Experience

From experience in many Initiatives, lessons can be learned about success factors. These can help an Initiative Leader to make good progress. Experience can also be used to identify potential pitfalls. Most of the pitfalls that may hinder successful implementation of PLM are known. They've been experienced by the pioneers. A known problem can be avoided. The Initiative Leader who is aware of potential barriers to success can take action to prevent them arising in the Initiative.

8.5.1 From the Trenches

8.5.1.1 Different Scope

In our experience, the scope of the PLM Initiative has nearly always been different. The only times that it has been the same have been when the company looks at the entire PLM Grid (Fig. 1.5).

One company we worked with wanted better management visibility into the progress, or otherwise, of product development projects. And they wanted product development time reduced by 15 %. And an effective obsolescence process. To meet these targets, they didn't need to address the entire PLM Grid.

In another company, the PLM Team had been told by top management of the intended growth in revenues for the following 7 years, and was expected to develop and implement a corresponding PLM Strategy. As a result, the Initiative looked at the entire PLM Grid. The Team wanted to be sure they looked at all the issues.

Another company had product developers on many sites working for many OEMs with different CAD/CAM/CAE applications. Top management was looking for a common project management approach across the company. They were hoping to include all development projects in a common portfolio, which would be managed with a common enterprise-wide process supported by a common enterprise-wide information system with a single database. And they wanted a multi-CAD solution enabling them to use resources and skills effectively across multiple projects and sites. And they wanted to improve requirements management, particularly for software development. Their PLM Initiative was focused on the product development part of the Grid.

Another company, as a result of acquisitions, had several part numbering systems. Their objective was to introduce a common part numbering system across the company. They didn't need an Initiative to address the entire Grid.

In another case, a company wanted to introduce a cross-functional Stage and Gate process and methodology supported by a PDM system. They had several different types of project activity, including Product Idea Management, New Product Introduction, Technology Development, Product Improvement and Technology Improvement projects. They wanted all of these project types to have the same overall structure and follow the same overall process, yet include the necessary specifics at the detailed level. One of their targets was to be able to see the status of all projects, and that of the overall Project Portfolio, at any time. Their Initiative didn't address the whole Grid, just a few parts.

One of our customers makes a more-or-less standard product. During the first decade of the twenty-first century, the number of customers grew rapidly, with many of them asking for small customisations to the product. The result was that, instead of having a single standard BOM, the company had very many slightly different BOMs. The objective set by top management was to identify modular BOMs. For that company, the scope was focused on product structure, product data structures, and data objects.

However, another customer, as a result of acquisitions, had several different PDM systems in different product divisions. The objective of top management was to decide whether they needed to have these different PDM systems, or could use the same system everywhere. In that case, PDM systems were obviously addressed in the description of the current situation. And so were product structures, product data structures, business processes and PLM applications.

The top management of another customer wanted to enable its product development unit in China to collaborate with units in other countries. The scope

	Time period	Productivity change	Development cycle change	Product cost change
Performance improvement approach				
Uncoordinated cherry-picking and lemon-squeezing	6 months	+4%	-3%	-3%
A short-term plan	1 year	+12%	-10%	-9%
A three-year Strategy and Plan	3 years	+40%	-39%	-28%
Integrated Vision, Strategy and Plan	5 years	+100%	-80%	-41%

Fig. 8.73 Different approaches, different results

addressed PDM systems and other PLM applications such as CAD/CAE/CAM applications.

Another company wanted to find out why it was getting so few new products to market. The scope focused on development and change processes, product structure and product data.

8.5.1.2 Different Approach, Different Result

It's important to make clear to everybody concerned by the PLM Initiative just what it's expected to achieve. There's a danger that people will expect strategic results from a tactical approach and a tactical investment. Figure 8.73 shows the results of one of our surveys into different types of approach.

The results of different approaches are very different. For example, cherry-picking projects give results fast, but the results are limited in their effect. Major gains come from long-term strategic approaches, not from short-term tactical projects.

8.5.2 Pitfalls for the PLM Initiative

Many pitfalls have been experienced by the pioneers of PLM. Known problems can be avoided. There are two main categories of pitfall. The first category is related to planning of the PLM Initiative (Fig. 8.74).

underestimating OCM	not developing PLM Vision and Strategy
underestimating the need for training and education	not developing a PLM Implementation Plan
underestimating data migration	not developing a PLM Roadmap
underestimating software costs	not developing a detailed PLM plan
underestimating the length of the Initiative	thinking that PLM is an IS project
underestimating the scope of PLM	not involving top management
not understanding business objectives	not involving users
not understanding user requirements	not aligning Vision, Strategy, Plans, KPIs
not understanding PLM is enterprise-wide	not appointing a senior leader for PLM

Fig. 8.74 Pitfalls of PLM planning

not appointing a great PLM Initiative Leader	implementing a system before designing the solution
not understanding business requirements	not starting with a successful "low-hanging fruit" pilot
holding off on starting the PLM Initiative	starting by customising
starting before everybody is ready	not involving users
believing you can't fail	ignoring important activities that slow progress
going for a Big Bang implementation	not measuring your success
getting IS to lead the Initiative	not promoting your success

Fig. 8.75 Pitfalls of PLM implementation

lack of skills	lack of recognition of Initiative scope
lack of standards	lack of recognition of Initiative complexity
lack of training	lack of recognition of need for PLM (compared to ERP, MES, KM)
lack of maturity	lack of recognition of the likely magnitude of change

Fig. 8.76 Big issues for PLM professionals

As an example of one of these pitfalls, one company we worked with appointed a PLM Initiative Manager who was hierarchically 5 levels down from the CEO. Not surprisingly, the Initiative failed.

The second main category is related to implementation (Fig. 8.75). During implementation, pitfalls can be found in many areas, ranging from finance to people.

During implementation, all sorts of problems may arise with funding of the Initiative. The underlying problem is often that there's not enough money to fund the Initiative properly. Usually enough money is found for purchase of applications, but not for other activities such as Project Management and Organisational Change Management. Even if the Initiative team thinks it's got enough money, there's a good chance that some of it will be withdrawn before it's been spent. Yet success hinges on the success of these activities.

Many of the pitfalls are related to people, which is why OCM is so important. Some issues may be related to top management, some to middle management, and some to users. Others are related to the Initiative Team. Top management may be a source of problems for reasons such as lack of commitment, lack of leadership, lack of support and lack of patience. Pitfalls at the middle management level may be due to conflicts with personal goals, empire-building, and fear of loss of power. Users may fear, for example, that a PDM system may play a Big Brother role, or may lead to job losses. The Initiative team may have its own issues to face (Fig. 8.76).

8.5.3 Examples of the PLM Dilemma

The dilemma described in Sect. 8.3 may seem absurd, but it arises in many companies. And it can continue for a long time before a true PLM Initiative is started. Here are some examples that I've experienced.

Company A, in process manufacturing, had been working for several years to deploy a cross-functional product development process. Asked about PLM, they replied that the CFO had said they would have to complete that deployment before starting an initiative in the area of PLM.

Company B, in consumer electronics, had recently launched a corporate effort to redefine all process maps to take account of globalisation, the new ERP application and the Web. It was a major effort, and executives were wary of starting a parallel PLM initiative. They said the company couldn't handle two major initiatives at the same time.

Company C, in the telecomms sector, was in a phase of merger and restructuring in response to global changes in that industry. The main priority was to get the existing Technical Information Systems, which were based on different architectures, databases and applications, and were on several different continents, to work together. This was a massive task and used all available resources. Nobody in the IS organisation had the time to work on PLM.

Company D, in the automotive sector, was proud of its application of CAD, CAM, CAE, PDM and Digital Manufacturing, but was faced by many problems in the area of Software Configuration Management. They wanted to solve that specific problem before starting an Initiative with a scope as wide as PLM.

Company E, in the aerospace industry, had several overlapping improvement projects on subjects that fell into the area of PLM. Some people had proposed consolidating these projects into one PLM Initiative. But the managers of the overlapping projects claimed that would slow down progress. Although the Engineering VP was supportive of a PLM Initiative, the CIO and the Quality VP were opposed.

Company F, in the mechanical engineering sector, was in a phase of rationalising existing Information Systems. PLM was seen as something fuzzy that couldn't be pinned down. They decided they would look at it when they had a clearer understanding of their new system architecture.

Company G, in the machine tool sector, wanted to reengineer its approach to product development to take better account of customer requirements. It didn't want to address Information System issues. Due to the cost of the ERP project, the CEO had forbidden any customisation of enterprise applications.

Company H, in the pharmaceutical sector, had hundreds of R&D projects running. One was a high-profile project to find a way to give management an overview of the current status of all R&D projects. That project had top priority, and no resources would be put into new projects until it had succeeded. PLM was on the back burner.

Company I, in the electronics sector, was reviewing, again, its Engineering Change process. Some of the people in the project thought the problem wasn't the change process, but the product structure. They wanted to take a more global approach to the problem. But the project charter didn't allow for that.

Company J felt that it had taken a piecemeal approach (Fig. 8.77) to its product-related applications and processes in the past, and thought it was missing

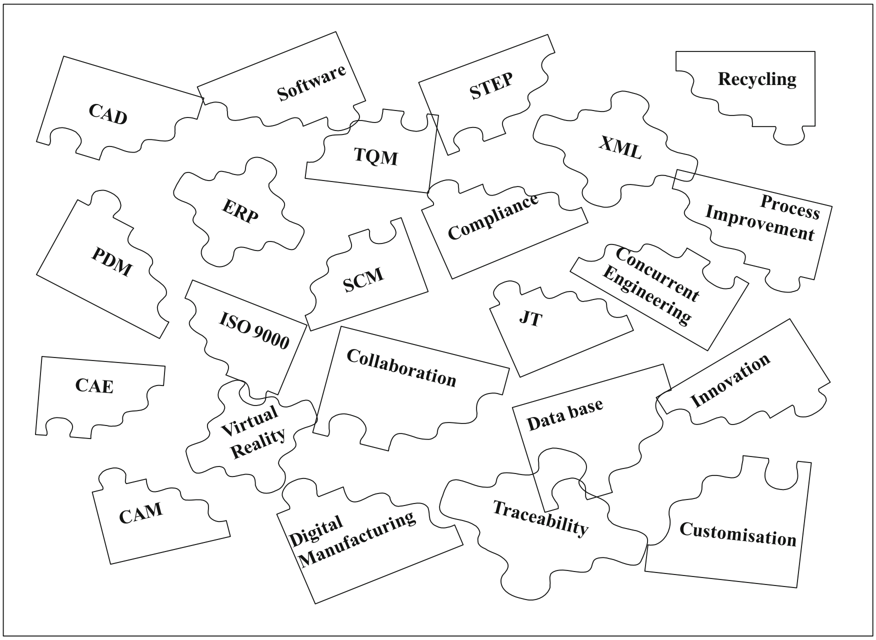


Fig. 8.77 A piecemeal approach

something. It was looking to solve that issue by bringing together all available resources for an ERP project.

Company K, in the plastics processing industry, had decided to stop all improvement projects until its markets started growing again. PLM was considered unimportant (Fig. 8.78), and was on hold.

Fig. 8.78 Some people underestimate PLM

Company L, in the power equipment industry, having recently terminated major projects to harmonise applications and improve business processes, was running a product structure optimisation project to enable more modularity and easier configuration for sales over the Web. Until that was completed, it would be difficult to start another project addressing the product.

Company M, in the medical equipment industry, had recently acquired a company making software for its products. It was looking to see how best to integrate operations and offer integrated solutions to its customers. As PLM wasn't in the annual plan, it wasn't addressed.

Company N, in the heavy vehicles industry, was struggling to find a way to deliver highly customised products with a Configuration Management application nearly 30 years old. There were several reasons why it wasn't easy to move forward. One problem was that the IS VP, the Engineering VP and the Marketing VP all claimed that PLM wasn't their responsibility.

Company O, in the electronics industry, finding that software was becoming a major part of its product, was looking at ways to integrate the development, purchasing and management of mechanical, electronic and software components. That project was called 2020 Vision, and PLM may be included among its objectives.

In Company P, in the electronics industry, the PDM Manager tried to start a PLM Initiative, but was told that the ERP project team already had that task.

In Company Q, in the engineering industry, the provider of the CAD system was restructuring its portfolio. There was a discussion as to whether this would be a good time to change to a single vendor for CAD and PDM. The subject of PLM had been side-lined until the vendor announced its plans.

Company R, in the medical appliance industry, successfully implemented a PDM application. However, when it tried to expand the scope of PDM, it found the application didn't have all necessary functionality. It had started to investigate other PDM applications. It wasn't sure how PLM related to PDM.

In Company S, part of a global electronics corporation, the PDM Manager tried to start a PLM Initiative but was told that PLM was a corporate activity, not a company activity.

8.5.4 Results of Use of the Ten Step Approach

The following examples show the benefits achieved by some companies that followed the Ten Step approach.

8.5.4.1 Understanding and Quantifying Options

This company wanted to understand and quantify the different options that had been suggested with 2D and 3D CAD, PDM, workflow management, BOM Management, product development process improvement, and a new development methodology.

The Ten Step Approach showed that there were three main options, and highlighted their different costs and benefits. In particular, it showed that the benefits of the low-cost option would be negligible, yet the other options would require significant management involvement. This led the company to appoint a PLM VP to drive the PLM initiative forward and achieve maximum benefit.

8.5.4.2 Managing the Post-acquisition Situation

As a result of an acquisition, this company had, at different sites, different CAD and PDM applications, and different product-related processes and methods. It wanted to identify the best solution and understand the associated implementation tasks and costs. The Ten Step Approach showed many additional issues and opportunities that hadn't been addressed, and led to a common PLM Strategy for all sites.

8.5.4.3 From PDM to PLM

This company had identified the need for a PDM system, and wanted help with specification of PDM system requirements, short-listing, benchmarking, project planning, cost evaluation and ROI. The Ten Step Approach showed the need for PLM (Fig. 8.79). It simplified the project and led to faster implementation.

8.5.4.4 Getting Started with PLM

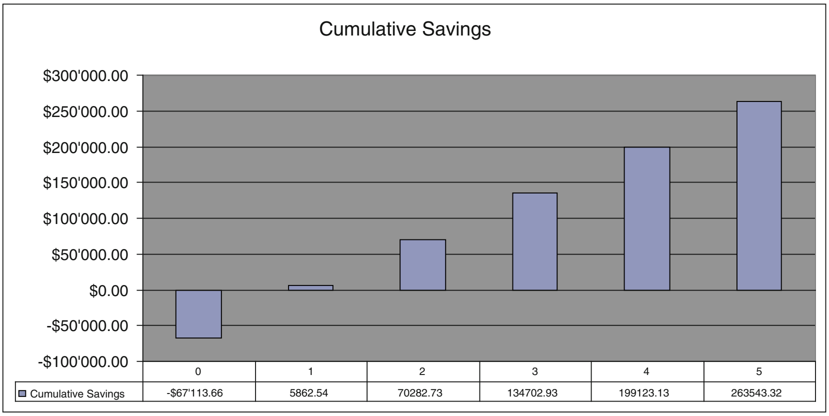
This company had identified the need for PLM. Management initially wanted some help with identification and detailing of different PLM concepts. The Ten Step Approach led into support for selection and implementation of the corresponding PLM applications.

8.5.4.5 Engineering Change Management

This company wanted help with the definition and automation of its Engineering Change process. The Ten Step Approach showed that the source of the problems it hoped to overcome with the EC project was outside the process. The proposed EC project was doomed to failure. The project was redefined to enable an increase in business value.

8.5.4.6 Identification of Benefits and Risks

This company had started a project to select and implement a PLM solution. As the size of the potential benefits became clear, management asked for external support



Costs						
	0	1	2	3	4	5
Current Anr	$0.00	$147'301.60	$147'301.60	$147'301.60	$147'301.60	$147'301.60
Cost with c	$0.00	$147'301.60	$294'603.19	$441'904.79	$589'206.38	$736'507.98
Potential Annual		$74'325.40	$74'325.40	$74'325.40	$74'325.40	$74'325.40
Investment	$58'557.66					
Annual	$8'556.00		$8'556.00	$8'556.00	$8'556.00	$8'556.00
Cost with n	$67'113.66	$141'439.06	$224'320.46	$307'201.86	$390'083.26	$472'964.65

IRR	NPV
5%	$219'940.65
15%	$156'272.83
50%	$50'464.10
100%	-$428.59
105%	-$3'282.02

Costs	0	1	2	3	4	5
Investment	$58'557.66					
Annual	$8'556.00	$0.00	$8'556.00	$8'556.00	$8'556.00	$8'556.00
Benefits						
		$72'976.20	$72'976.20	$72'976.20	$72'976.20	$72'976.20
Annual Savi	-$67'113.66	72976.20	64420.20	64420.20	64420.20	64420.20
Cumulative	-$67'113.66	5862.54	70282.73	134702.93	199123.13	263543.32

Investment	Annual benefit
$67'113.66	$72'976.20
Payback (years)	Payback (months)
0.92	11

Fig. 8.79 Showing the value and ROI of the project

to validate the findings and identify potential risks. The Ten Step Approach quantified a realistic ROI. Risks were identified, classified and quantified. A risk management approach was implemented.

8.5.4.7 Two Proposed Solutions

This company had received a proposal from its CAD application vendor for a PLM solution, and a very different proposal for PLM from its ERP vendor. The Ten Step Approach highlighted the differences between the two proposals and showed how they related to business objectives. This allowed the CFO to launch an opportunity study to show which approach would be best for the company.

8.5.4.8 Findings

The above examples show how the Ten Step Approach to PLM Launch tends to broaden and deepen a company's understanding of PLM. It raises the level of awareness among executives, eventually leading to a PLM Initiative of greater benefit to the company.

8.5.5 Common Features of PLM Initiatives

8.5.5.1 A Unique Initiative Benefiting from Experience of Others

Although all PLM Initiatives are different, they have some common features. As a result, although each company has to build its own PLM Initiative, it can draw on experience from other companies.

8.5.5.2 A Multi-year PLM Initiative

Full achievement of PLM can be expected to take a lot of effort and a long time. That's normal. PLM is a major business activity running across the complete product lifecycle and the Extended Enterprise. PLM has a wide scope, and the PLM environment is complex. The knowledge about the product may be in many different places, and in many different applications. Clarifying and straightening out processes, data and applications can be time-consuming. The processes and methodologies to propose, define, manufacture, support, upgrade, retire and recycle the product may not be aligned, or may even not exist. To achieve PLM will require a lot of effort over many years. A PLM Initiative will run for several years. It isn't realistic to expect that everything will be done at once.

8.5.5.3 A PLM Initiative Containing Many Projects

In theory, it might be possible to achieve all the PLM objectives in one project. However, a single, huge, multi-year project is likely to end in disaster. In reality, it's better to run a formal PLM Initiative containing many smaller, shorter, more focused projects. Without a formal PLM Initiative, there's the danger that some important activities will slip out of view, some won't occur, some activities will overlap, the results of some activities will conflict, and some important decisions won't be taken. The end result is likely to be project failure, or downgrading of objectives. Many of the potential benefits of the PLM Initiative will be lost.

8.5.5.4 Phase the Initiative, Don't Chop It Up

Because a PLM Initiative addresses so many components such as products, processes, people, data, and applications, it may not be clear initially how a company can handle such a huge project. It's even possible that someone will suggest that it's not possible to manage an activity with such a wide scope. They may suggest cutting off a piece of PLM and focusing on that one piece. For example, some people might want to focus on the Product Definition phase of the product lifecycle, and ignore the other phases. Others may want to focus on IS. By focusing their resources in one area, they may hope to get a better understanding that will lead to faster progress and better results.

However, the danger of initially restricting the scope in this way is that it may result in the loss of many of the potential benefits of PLM. It's by bringing together, and joining up, previously disparate and fragmented activities, applications and processes, that PLM overcomes the many problems that result from the old unconnected approach. Cutting off a piece of PLM runs the risk of leading to a new fragment with similar problems to those of older fragments.

Fortunately, there are alternatives to reducing the potential size of PLM by cutting off a piece of PLM and addressing it separately. The first step should be to look for a structure and organisation for PLM that will help simplify its understanding and implementation. The Vision and Strategy should be defined. When this has been achieved, the many opportunities within the scope of PLM can be prioritised. And an implementation roadmap built with manageable phases.

8.5.5.5 Order of Components

Questions are often asked about the order in which a company should address PLM components such as processes, data and applications. For some activities, it's clear that they can't be done together. For example, after PLM has been successfully deployed, it must be maintained. It can't be maintained before it's been deployed. However, for other activities, it may be less clear in which order they should be carried out. For example, it may not be clear if a process should be improved before it's automated, or if it should first be automated. And then improved once the automated process has been used and understood.

The order often depends on the situation in the company. Sometimes it will be appropriate to address processes first, sometimes data, sometimes products. In a start-up situation, the product data, which identifies the product, needs to be identified first. Then the business process to create it can be defined. In a mature company, though, with the product data defined, it's likely to be the process which needs to be addressed first with a view to improvement. Probably there will have been many uncoordinated changes and additions to the process over the years, and the potential for improvement is likely to be high. In a start-up situation, after the product data and process have been defined, then an application can be selected to support the process. In a mature company, with the product data and process defined, the functionality of a new application could enable improvement of the process.

In general, a balanced approach, depending on the current situation, is best. For example, some work should be done on processes, and then some work should be done on product data. Then a pause to review the results. Then some more process work, and then some more work on product data. The two will be addressed side-by-side in the effort to achieve the objectives.

8.5.5.6 Step-by-Step or Big Bang

Companies can choose to move forward towards the future situation with a step-by-step approach or a Big Bang.

A Big Bang approach aims to implement all the changes at the same time. It has the advantage that, by addressing all changes at the same time, a great improvement can be made quickly. On the other hand, failure will lead quickly to a great disaster. Although a Big Bang approach may appear quick and simple, the result is generally the opposite. A successful Big Bang only comes after a long preparation phase, during which many people lose interest and motivation because of the lack of results.

A step-by-step approach moves the company forward from the current situation in clearly-understood increments. It has the advantage that each step is so clearly understood that it should succeed. And, as each step is implemented, people can see and appreciate the progress. Should any problems occur, they can be resolved before they get out of hand. On the other hand, the approach runs the risk that the gains due to many small steps will never add up to a significant benefit. And that the Initiative will be stopped before all the steps have been completed.

8.5.5.7 Starting Place

The decision as to where the initial implementation of PLM should take place will vary from one company to another. In some companies, one function is seen as a strategically important function, and able to act fairly independently. Initial activities could be targeted on this function. In other cases, the decision can depend on the size of the gap between the current situation and the future situation. It can also depend on previous experience with similar projects. Starting the PLM Initiative with a short, simple activity that will soon show success can lead to increased acceptance.

8.5.5.8 A Good Initiative Manager

A PLM Initiative, made up of many individual projects of various sizes, can be compared to a Development Program, with multiple development projects, that's set up to develop a series of related products. There's a need for leadership of the overall Program, but equally importantly, each of these projects will have its own project leader, objectives and tasks. In the case of the PLM Initiative, the leaders of the individual projects report to the PLM Initiative Manager.

In theory, a PLM Initiative can be led by anyone who can run a complex, cross-functional project. In practice, it's good to have a leader who has experience with the company's products at different phases of the lifecycle, who can handle the cross-functional aspects of PLM, and who has experience of managing the various components of PLM, such as applications, processes, product data and methods.

8.5.5.9 A Cross-Functional Challenge

A PLM Initiative is enterprise-wide, enterprise-deep. It involves people at all levels of the company and from all the functions involved across the product lifecycle.

A PLM Initiative is challenging. It has a wide scope. It addresses the product's entire lifecycle. It may address products, product data, applications, processes, organisation issues, people, methods, and equipment. Most companies aren't organised for such an Initiative. They don't have organisational structures that operate across such a wide area.

Many people in the company will find it difficult to address such a wide scope. Usually people are focused on a particular area, and want to improve what they understand. IS specialists want to implement IS solutions; business process experts want to implement process solutions. However, in a PLM Initiative, it's often necessary to make interrelated improvements simultaneously in different parts of the company.

PLM isn't the responsibility of just one function or department. PLM can't be the responsibility of the Engineering department, because Engineering isn't responsible for the product all the way across the lifecycle, for example, when it's in the field. Similarly, PLM can't be the responsibility of the Service department, because Service isn't responsible for the product all the way across the lifecycle, for example, when it's under development. PLM can't be the responsibility of the Information Systems Department, because IS isn't responsible for a company's products at any time. PLM can't be the responsibility of the Finance Department, because Finance isn't responsible for a company's products at any time.

A PLM Initiative can be particularly challenging for the IS Department. Many IS-related questions need to be answered (Fig. 8.80).

8.5.5.10 Learning and Understanding Takes Time

Experience shows that it can take longer to make progress with PLM than expected. Often, one of the reasons for this is a need to broaden the understanding of PLM issues among business executives. Another is the difficulty of identifying the best approach to PLM and justifying the business case.

8.5.5.11 The Need for OCM

A PLM Initiative is a major improvement activity that's likely to result in changes that affect many people throughout the company. In most companies it takes a long time and a lot of effort to bring about change. This is likely to be the case for the

Issue	*Questions*
product data security	Product data is valuable. Where do you put it? How do you keep it secure? How do you protect it? How do you enable reuse?
large data files	Network. Share? Across sites? Replicate?
enterprise-wide	Can your architecture handle it?
step-wise implementation	Can you scale appropriately?
Internet of Things	How does the IT Strategy match PLM IoT needs?
Mobile	Does the IT Strategy match PLM mobility needs?
analytics	Does the IT Strategy match PLM analytics needs?
Cloud	Will your Cloud Strategy work for PLM?
Social	Does the IT Strategy match PLM social needs?
integration	How much integration? Who? Cost?
service providers	Do you know experienced partners?
role-based user interfaces	Can you meet user requirements?
multiple environments	How many?
performance measurement	Which scripts will you propose?
licencing	Do you understand the end point?
helping the business	What will you propose?

Fig. 8.80 Some PLM issues and questions for the CIO

changes related to PLM. Recognition of the need for a clearly defined and professionally managed change activity is a key feature of a successful PLM Initiative. It's important to understand that change is a major activity in its own right, and is a project in its own right, with its own objectives, activities, tools, techniques and metrics.

8.5.6 Top Management Role in the PLM Initiative

8.5.6.1 Appoint a PLM VP

A company's products are at its heart. The company's revenues come from its products. More than 30 % of its business processes may be within the scope of PLM. More than 30 % of the people in the company may work in these processes. Perhaps the most important activity for top management is to appoint a PLM VP, and give them the responsibility of defining the objectives for PLM, defining the Vision, Strategy and Plan, and implementing the plan.

8.5.6.2 Upfront Planning

A lot of upfront planning is needed to define the way that a company will work in the future PLM environment. This may appear to some executives as a waste of time and effort. However, in the long run, it's better to work out first how the environment will be managed in the future. PLM needs to be aligned with business objectives. There needs to be agreement on the value of PLM and on the implementation roadmap. The alternative of starting projects without a clear plan is unlikely to succeed.

8.5.6.3 Involvement and Commitment

Top management involvement and commitment is a key success factor in a PLM Initiative. For a successful Initiative, top management has to take the lead and show the way. The potential benefits of a PLM Initiative are huge, but the Initiative is cross-functional, tough and risky. Without top management support and involvement it's likely to fail. The Initiative will change the way the company works. Top management should set the objectives, track project progress, make sure the project stays on time, on budget and on scope. If things aren't working out, top management needs to take action to put the project back on track. If the project faces a major issue, top management must take responsibility.

8.5.6.4 Prescriptive Approach

A prescriptive approach is required with PLM. In other words, the company has to define what must be done across the product lifecycle, and then everyone has to follow these rules. The opposite approach, "anarchy", is that everyone would decide locally what they want to do. The result would be problems when people in different areas try to work together.

8.5.6.5 Clear and Common Terminology

A clear and common terminology is needed company-wide. For example, people need to agree on the meaning of words such as product definition, product requirement, product specification. Another set of words about which people may have different understanding is version, variant, release, option, model, revision. Use of the term "Portfolio Management" needs to be clarified and standardised. It's often used with different meanings.

8.5.6.6 Architectures and Models

Architectures and models describing the product and the PLM environment have to be defined. In the everyday world it's normal practice for architectures and models to be prepared before building objects such as skyscrapers, cars and computers. In the world of PLM they are needed to describe and communicate how a company's resources (processes, people, data, products, applications, etc.) are organised.

8.5.6.7 Digital Company

Digital Product, Digital Manufacturing, Digital Support …. the twenty-first century is the Age of the Digital Company. The change from analogue to digital is fast. Top management needs to keep abreast of changes, respond, and in particular be sure that it hires people who can think and act in the digital environment.

8.5.6.8 Product Strategy

To enable PLM, companies need a Product Strategy. In the past, many companies haven't had such a strategy. Their product-related activities have resulted from other strategies such as a Marketing Strategy, an R&D Strategy and a Manufacturing Strategy. PLM supports a strategy of Managed Complexity and Change (MCC). This is the typical strategy for an OEM with its roots in high-cost countries and a desire to provide products worldwide. Offering complex, frequently updated products through a global capability, the strategy puts the company on a playing field on which few can compete. In this strategy, the OEM will often define major assemblies, then outsource their development and production to Global Complex Assembly Providers. An OEM with an MCC strategy has to make money for its shareholders, but it doesn't have to make its product. It can outsource to the best development, manufacturing, sourcing and delivery networks. The OEM focuses on managing its portfolio of products, its product deployment capability, customer requirements, product architecture, product specifications, supplier management, system integration, final assembly and customer feedback.

8.5.6.9 Product Portfolio and Product Architecture

The strategy of Managed Complexity and Change implies careful definition of the Product Portfolio and the architecture of products. The objective is to be able to launch worldwide, in quick succession, many new products based on a small set of common platforms, modules and interface components. The basic platforms should change infrequently and be globally as similar as possible. The platform may represent 80 % of the product, the modules 20 %. As much as 90 % of a new product may be the same as for a previous product. New modules and low-cost facelifts to existing modules will enable the customer to be presented frequently with a succession of 'new' products. Platforms, modules and interface components need to be designed so that they can be assembled in different ways to give customer-specific products.

8.5.6.10 Model the PLM Environment

A model of the product lifecycle environment will show how the components of the PLM environment are related, and how changes to the components can affect performance measures. The model helps show how resources should be addressed to improve performance. A model can show, for example, whether the company would achieve a greater benefit from implementing a particular plan to improve processes, from implementing a specific set of actions to improve product data, or from purchasing a particular PLM application.

8.5.6.11 PLM Thought and Action

So long as there are products, and companies wanting to improve performance, so long lives PLM and the desire to improve PLM performance.

Running around like a chicken without a head, trying to implement all sorts of new PLM methods and applications, without thinking about an overall vision and approach, is unlikely to lead to success. But, sitting in an ivory tower, dreaming of visions and strategies, isn't going to lead to success either.

Between 2000 and 2015, we helped more than thirty companies with their PLM Initiatives. In several cases, we worked with them for more than 5 years, sometimes at the strategic level, sometimes down in the details of process steps, data relationships and customisation of application functionality. Based on this experience, it's clear that, for PLM success, both thought and action are needed. As Henri Bergson wrote, "Think like a man of action, act like a man of thought."

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