Product Lifecycle Management

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Product Lifecycle Management

Third Edition

With 62 Figures and 5 Tables

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Preface

The significance of product lifecycle management (PLM – Product Lifecycle Management, formerly referred to, in a narrower frame of reference, as PDM – Product Data Management) is increasing, especially for companies in the manufacturing, high technology, and service industries. Product and component lifecycles are shortening while, at the same time, new products must be delivered to market more quickly than before. Many manufacturing and service companies are also trying to grow out of a bulk provider role. In the future they will be providing configurable and flexible solutions rather than just individual products. This leads companies to form networks in which each actor specializes in the planning, manufacture or integration of products in a certain field. Information concerning common products must pass quickly, faultlessly, and automatically between companies so that they can compete effectively in international markets.

In today's industrial production, therefore, PLM is an essential tool for coping with the challenges of more demanding global competition and ever-shortening product and component lifecycles and growing customer needs. New, better and more flexible products must be introduced into markets more quickly, with more profit and less labor, and the lifecycle of each product must be better controlled, for example, from financial and environmental perspectives. Fierce competition in global markets drives companies to perform better. In order to perform well financially, companies must be able to make informed decisions concerning the lifecycle of each product in their portfolio. Winner products must be introduced into the market quickly and poorly performing products must be removed from the market. To do this well, companies must have a very good idea of the lifecycle of each product. A good command of product and process definitions over a large product portfolio requires that ways of operation and IT-systems must support each other flawlessly.

Today's complex products require the collaboration of large specialist networks. In this kind of supplier and partner network, product data must be transferred between companies in electronic form, with a high level of information security. Overall, PLM can also be considered a tool for collaboration in the supply network and for managing product creation and lifecycle processes in

today's networked world, bringing new products to the market with less expenditure of time and effort.

This book is intended as a manual of product lifecycle and product information management. It will support PLM/PDM concepts and system implementation projects as well as providing ideas for developing product data and product lifecycle management in businesses.

The book will be useful, for instance, to:

1. Product managers
2. Business managers
3. R&D organizations
4. PLM-projects and project-personnel in the companies, documenting managers, product creation and R&D Organizations, sourcing and procurement, after sales organizations, business development organizations, IT-managers, IT-personnel
5. PLM-consultants
6. After sales organizations
7. Educational organizations
8. University students

The book deals with the term PDM in its wider significance: the context in which the proper modern term or acronym is PLM – Product Lifecycle Management. We think of PDM, or Product Data Management, as a useful tool for controlling product-related information as well as the lifecycle of a product.

The two acronyms PDM and PLM are closely associated; the main difference is one of scope and purpose. Whereas PDM is mainly a set of tools and methods aimed at efficiently managing product data, PLM is a holistic approach that uses a wide range of different concepts, technologies, and tools, which extend to groups beyond the functions of a company or even a supply network in order to manage and control the lifecycle of a product.

The starting point for this book has been that PDM really covers the whole lifespan of the product and the whole spectrum of product data. It is not concerned only with product-related CAD files. We are using the term PLM – Product Lifecycle Management – to describe the wider frame of reference of product data. PLM, in this book, refers to this wider totality, especially with the aim of settling the continuously changing and flickering terminology of the field.

Traditionally PLM has been a business concept for the tangibles business and especially for goods manufacturing. This tradition is very visible in this book

also. However, the importance of PLM in the intangibles (e.g. software and services) business has grown dramatically during the past two years and therefore some aspects of using PLM in the intangibles business has been added to the third edition of this book. When reading this book, the reader should bear in mind that even though most of the chapters have been written initially with a tangibles business mindset, most of the principles explained and featured are applicable also in the intangibles businesses. Chapter 9 of this book is new and has been written solely for the services business.

Chapters 2, 3 and 4 cover the fundamentals and concepts of product lifecycle management and terminology. Chapter 5 considers the different roles of information processing systems within the company from the viewpoint of product information management. Chapters 6, 7 and 8 survey the deployment and completion of implementation projects for PLM systems; case examples concretize the use of systems in companies making different kinds of products. Chapter 9 will focus on service products and the utilization of PLM in service industry. Chapters 10, 11 and 13 envisage PLM concept from a markedly wider perspective, thinking in terms of the development of the business. The final chapter considers the significance of cooperation or collaboration between companies and the role of PLM in this.

Antti Saaksvuori
In February 2008 Anselmi Immonen

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Chapter 1 – Introduction

Product lifecycle management makes it possible to command the whole lifespan of a product and the information connected with it. Efficient product lifecycle management enables companies to compete successfully in international and global markets.

What is a product?

Usually, when talking about products we mean tangible products i.e. goods. The term goods refers to physical, tangible products that can be owned, traded, and distributed to different places at different times without changing their identity. However, a product in a modern world can also be something very intangible such as a piece of software, a piece of knowledge or an algorithm or a formula. They are products as much as tangible products are.

When referring to a product in this book, we refer to three different kinds of products:

1. Goods meaning physical, tangible products

2. Services (a definition for services will be addressed in more detail in chapter 9)

3. Intangible products meaning non-physical products that are not services. For example:

    - Software
    - An algorithm

PLM: What is it?

In many ways, product data management can be seen as a subset of PLM. First EDM (Engineering Data Management) and then PDM (Product Data Management) emerged in the late 1980s as engineers in the manufacturing industries

recognized a need to keep track of the growing volumes of design files generated by CAD (Computer Aided Design) systems. PDM allowed them to standardize items, to store and control document files, to maintain BOM's, to control item, BOM and document revision levels, and immediately to see relationships between parts and assemblies. This functionality let them quickly access standard items, BOM structures, and files for reuse and derivation, while reducing the risk of using incorrect design versions and increasing the reuse of existing product information.

However, the benefits of operational PLM go far beyond incremental savings, yielding greater bottom line savings and top-line revenue growth not only by implementing tools and technologies, but also by making necessary, and often tough, changes in processes, practices and methods and gaining control over product lifecycles and lifecycle processes. The return on investment for PLM is based on a broader corporate business value, specifically the greater market share and increased profitability achieved by streamlining the business processes that help deliver innovative, winning products with high brand image quickly to market, while being able to make informed lifecycle decisions over the complete product portfolio during the lifecycle of each individual product.

The scope of product information being stored, refined, searched, and shared with PLM has expanded. PLM is a holistic business concept developed to manage a product and its lifecycle including not only items, documents, and BOM's, but also analysis results, test specifications, environmental component information, quality standards, engineering requirements, change orders, manufacturing procedures, product performance information, component suppliers, and so forth.

On the other hand, modern PLM system capabilities include workflow, program management, and project control features that standardize, automate, and speed up product management operations. Web-based systems enable companies easily to connect their globally dispersed facilities with each other and with outside organizations such as suppliers, partners, and even customers. A PLM system is a collaborative backbone allowing people throughout extended enterprises to work together more effectively.

Operational efficiencies are improved with PLM because groups all across the value chain can work faster through advanced information retrieval, electronic information sharing, data reuse, and numerous automated capabilities, with greater information traceability and data security. This allows companies to process engineering change orders and respond to product support calls more quickly and with less labor. They can also work more effectively with suppliers in handling bids and quotes, exchange critical product information more smoothly with

manufacturing facilities, and allow service technicians and spare part sales reps to quickly access required engineering data in the field.

In this way, PLM can result in impressive cost savings, with many companies reporting pay-off periods of one to two years or less based solely on reduced product development costs. PLM also enables better control over the product lifecycle. This gives opportunities for companies to boost revenue streams by accelerating the pace at which innovative products are brought to market. Excellent lifecycle control over products also gives new opportunities to control product margins more carefully and remove poorly performing products from the markets. This set of benefits, driving top line revenue growth and bottom line profitability, makes ROI extremely compelling, with some industry analysts characterizing PLM as a competitive necessity for manufacturing and software businesses and today also for service businesses.

Product Lifecycle Management: background

Product lifecycle management (PLM) is a systematic, controlled concept for managing and developing products and product related information. PLM offers management and control of the product (product development, productizing and product marketing) process and the order-delivery process*, the control of product related information throughout the product life cycle, from the initial idea to the scrap yard (figure 1). Almost without exception, the PDM and PLM abbreviations also refer to information systems developed to manage product lifecycle and product related data.

The core of product lifecycle management is the creation, preservation and storage of information relating to the company's products and activities, in order to ensure the fast, easy and trouble-free finding, refining, distribution and reutilization of the data required for daily operations. In other words, work that has once been done should remain exploitable, regardless of place, time or – within prescribed limits, naturally – data ownership. At the same time, the idea is to convert data managed by the company's employees, skilled persons and specialists into company capital in an easily manageable and sharable form – as bits.

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* In many fields of manufacturing industry, the order-delivery process is also called the customer process due to the frequency of build-to-order production. The fulfillment of the customer's purchase order, i.e. the manufacture and delivery of the actual product, is already allocated to a certain customer and to a certain order. In this context the customer process is considered a synonym for the order-delivery process and does not refer to customer relations management.

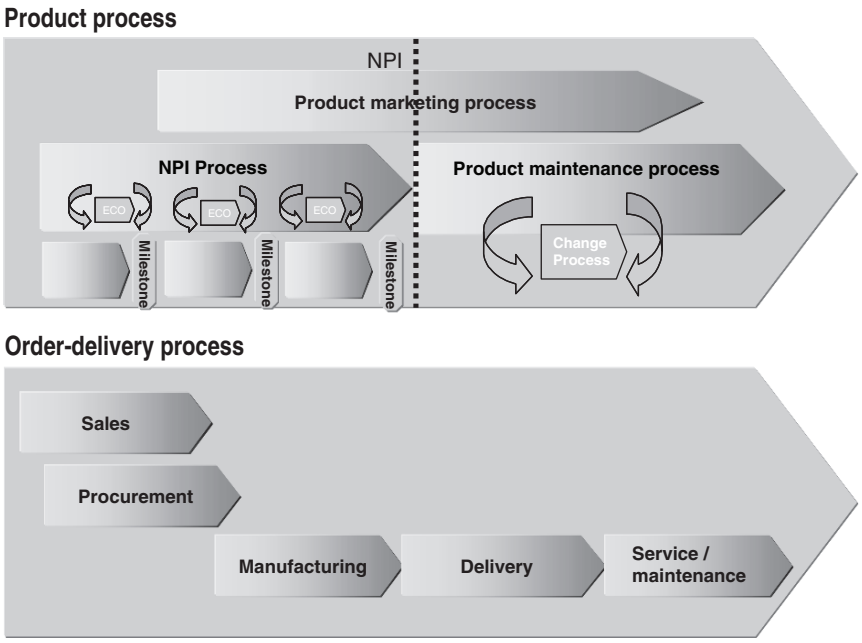

Figure 1. Product (product development, productizing, product design maintenance and marketing) process; order and delivery (customer) process. (Note: In many fields of manufacturing industry, the order-delivery process is also called the customer process due to the frequency of build-to-order production. The fulfillment of the customer's purchase order, i.e. the manufacture and delivery of the actual product, is already allocated to a certain customer and to a certain order.) NPI refers to New Product Introduction.

Recently capital goods manufacturers in particular have tried to find new business opportunities in services, especially the after market services that surround products. Traditional manufacturing industries are increasingly interested in offering their customers a wider range of value added services. The objective is to provide services covering the whole life cycle of the product, which – especially for capital goods – can be as much as 30 years. On the other hand, product and component life cycles are shortening while new products must be delivered to market more quickly than before.

From this perspective the term PDM gains a wider meaning, and now we more often speak of Life Time Service of products and management of the life cycle of the product, from PLM (Product Life cycle Management). The management of the whole life cycle of products and related services is becoming a central factor in certain fields of industry. In addition to PLM and Life Time Service, the term

Extended Product is also used of this wider outline in some connections. Service functions are connected to the concept of the extended product both before the production and after the delivery of the product.

Customer guidance is a driving force behind companies. Competition is hard in international markets. Companies must be able, cost-efficiently, to serve customers better and react more quickly to changing markets. Combined with cost-effectiveness, reaction and service capacities are closely related to rapid product development and order/delivery processes and fast, controlled reactions to changes in market conditions. It should be possible to change the product's design or development and production processes quickly, even if it is often for a single client.

One feature of the modern business world is powerful inter-company networking. Individual products are generally born from cooperation between companies, each of which is responsible for some part of the product's planning, component preparation or assembly. The task of the principal (owner of the product trademark or product concept or OEM – Original Equipment Manufacturer) or the company selected for the role of principal is the management of the whole network and the coordination of cooperative effort. The management of an extensive and scattered network of subcontractors and partners is not easy. It requires very effective data management.

Corporate challenges

Large companies handle considerable amounts of data. The manufacturer of millions of units of complex, customer-tailored products across a broad product range clearly cannot operate globally without effective data management. Software and service companies often create and produce extremely complex products with high level of configurability. In these businesses it is absolutely necessary to master the definition of each product in order to be able to design the product functionality further as well as handle the delivery, maintenance and support of the product efficiently.

On the other hand, the data produced by existing information system applications is already in an electronic format. In any case, it is electronically stored somewhere. This makes possible the inauguration and effective exploitation of information systems designed for product lifecycle management.

In a networked operational business environment, making changes to product designs or product implementations is also a big challenge, when data integrity

must be preserved regardless of circumstances. All the interested parties must have access to the latest version of the documentation of each product. In addition, it should be possible to see the effect of changes to product elements as the changes are planned.

Modern industry almost invariably uses various information systems as aids in planning, production, delivery and customer service. This demonstrates one of the challenges of the networked operational environment. Different parties each have their own systems, and yet information and files must be transferred, used and refined throughout the network. The necessary technology is available. Its application is a little more difficult, but not impossible.

The practical application of product lifecycle management – the implementation of the PLM system within the company – is an extensive project involving a detailed and laborious definition of various features of the business processes of the company. It is important, indeed essential from the system implementation point of view, that the company is thoroughly acquainted with its own business processes. Additionally, it is important to note that the storage, management and use of product data affect a large part of the company's organization.

It is also useful, when implementing a product lifecycle management system, critically to scrutinize the company's operational models, processes and information models. If necessary, the processes and information models must be changed and renewed. It is worth noting that the implementation of a first PLM-system within a company often involves large changes in its processes. This naturally causes resistance within the organization, prolonging the adoption of new processes and the PLM system itself, while also increasing the need for staff training.

In this book, we examine the basics of product data and product lifecycle management and review the nature and extent of the development project required for the initiation of systematic product lifecycle management. In addition, we examine points essential to the smooth and successful completion of a PLM information management project. We also consider the significance of product lifecycle management from the viewpoint of company-wide operational development and the move to electronic business.

Chapter 2 – Fundamentals

This chapter introduces the basics and the central terminology of product lifecycle management. The chapter presents the area of application of PLM and the core functions of an information processing systems adapted to the practical realization of product lifecycle management.

Product data or product information

Product data refers in this context to information broadly related to the product. Product data can be roughly divided into three groups:

1. Definition data of the product
2. Life cycle data of the product
3. Metadata that describes the product and lifecycle data

The definition data of the product – determines physical and/or functional properties of the product – i.e. form, fit and function of the product – describes the properties of the product from the viewpoint of a certain party (e.g. customer or producer) and connects the information to the interpretation of the party in question. This group includes very exact technical data as well as abstract and conceptual information about the product and related information. This group of information also includes the images and conceptual illustrations that characterize the product. So more or less this set of information could be characterized being a complete product definition. The wide spectrum of information and the difference in the contents of definition data can easily cause problems, owing to different interpretations and contexts.

The life cycle data of the product – is always connected to the product and the stage of the product or order-delivery process. This group of information is connected to technological research, design and to the production, use, maintenance, recycling, and destruction of the product, and possibly to the official regulations connected with the product.

The Meta data – is information about information. In other words, it describes the product data: what kind of information it is, where it is located, in which databank, who has recorded it, and where and when it can be accessed?

The concepts of product data or information model and product model, for which the term product structure is nearly always used as a synonym, and the acronym BOM (Bill of Materials) are also closely connected to the product data. Actually, BOM refers to a manufacturing part list (i.e. not a hierarchical structure) so it is not strictly speaking the same as a product structure. The part list is typically a single-level, flat list of the necessary components used by the manufacturer in assembling the product. The list does not contain a product structure, assembly or component hierarchy.

A product data or information model is a conceptual model of the product in which information on the product and the connections between various information elements and objects are analyzed at a general, generic level.

The product data – the information about the product to be created – lies at the core of the integration of the functions and business processes of a manufacturing company. The creation, development, handling, division and distribution of information connect the immaterial and material expertise of the organization. An actual physical product includes both. On the other hand, intangible products, for example software and services, always lack the physical aspect. Therefore it is extremely important to try to concretize the functions and the features of an intangible product to the same level as for physical products, i.e. transforming the functions and features into information objects (items) that can be handled as they were physical entities.

The external and internal functions of the company use and produce product data in their daily business. The internal functions that produce product information include the planning, design and engineering functions related to the product, as well as the procurement, production and customer service organizations. The external functions that produce and utilize product data include, for example, collaborative partners in maintenance services, design and engineering, manufacturing and assembly.

The need for the collaborative use of product data will appear clearest in the functions closest to the actual product process for the whole life cycle of the product – in networked product design and creation and in the networked functions of manufacturing and after market services. The control of product data is very much emphasized by companies operating in a networked environment.

Product Lifecycle Management (PLM)

Product lifecycle management, or PLM, does not refer to any individual computer software or method. It is a wide functional totality; a concept and set of systematic methods that attempts to control the product information previously described. The idea is to control and steer the process of creating, handling, distributing, and recording product related information. According to the definition by Kenneth McIntosh some years ago:

Engineering data management – EDM (currently the appropriate acronym would be PLM) is a systematic way to design, manage, direct, and control all the information needed to document the product through its entire lifespan: development, planning, design, production, and use.

In daily business, the problems of product lifecycle management typically become evident in three different areas:

1. The concepts, terms and acronyms within the area of product lifecycle management are not clear and not defined within companies. This means that the information content connected to certain terms is not clear and the concepts how to utilize to the product related information are even fuzzier (for example the definition: what is product lifecycle and what are its phases).
2. The use of the information and the formats in which it is saved and recorded vary. Information has usually been produced for different purposes or in some other connection but it should still be possible to utilize it in contexts other than the task for which it was produced: in a different locality or even in a separate company. An example might be the use in e-business sales, of a product structure originally created during the design phase. The lack of an integrated information processing system often means that the product structure must again be manually fed into the e-business sales system.
3. The completeness and consistency of information produced in different units, departments or companies cannot be guaranteed. This problem arises when the product data is produced and stored on different data media or even as paper documents, and when the parties concerned have different approaches to the protection and handling of information. One practical problem can be clarifying the location of the latest version of a certain document.

> For example, in many companies a file server in the local area network is the agreed storage place for completed and released product documentation. However, shortcomings in the processes, standards, and tools for information production and management can cause some erosion of the operations model in practice. People and organizations begin to update the same information on their own storage, for example on their own workstations, and they share information from there. Nobody knows for sure whether the latest version is located in the agreed place.

Nowadays, product lifecycle management is, in practice, carried out almost without exception with the help of different information processing systems. However, it does not always have to be like this. In many companies, simple actions can be taken to develop information management without a special and dedicated information processing system. An agreement, an operations model, or a set of common practices and standards for information handling can be the basis of development work. The creation and following of common modes of action is the key to improvements in the creation and analysis of information.

It is possible to solve many of the problems and situations described above using information-processing systems that support product lifecycle management. Information processing systems have evolved quickly during the last few years; and yet it has not been possible to remove all problems. The worst problems, at a practical level, result usually from different modes of operation, the wide spectrum of different software used to produce the information, functional differences in software, and the numerous interfaces between different information processing systems.

Product lifecycle management is above all the management of processes and large totalities. How and at what level each company carries out its own product lifecycle management always depends upon the viewpoint from which problems are examined as well as company objectives and strategies in this area. It is therefore extremely important that the operation and core business processes of the company be described in depth before implementing a PLM concept and IT-system. In practice, this means that the required specifications of the TO BE of future processes as well as the PLM concept framework must be set to match the high-level objectives of the business and the future visions of the company. In addition to careful selection of requirements for product lifecycle management, business processes must be described in detail. The resulting product lifecycle management solutions differ considerably as they are based on the individual strategy and business architecture of each company. They reflect different objectives and priorities and emphasize different areas and functions of PLM.

Product lifecycle management concept

The product lifecycle management concept, at its simplest, is a general plan for practical product lifecycle management in daily business at the corporate level, in a particular business or product area. It is a compilation of business rules, methods, processes, and guidelines as well as instructions on how to apply the rules in practice. Usually, the product lifecycle management concept covers at least the following areas:

1. Terms and abbreviations used in this field (definition of product, lifecycle, lifecycle phases, etc.)
2. Product information models and product models
3. Definition of products and product-related information objects (items, structures, product-related documents, definition of product information, etc.)
4. Product lifecycle management practices and principles used and applied in the company (how products are managed throughout their lifecycle, identification of information management principles such as versioning principles, information statuses, etc.)
5. Product management related processes
   (a) Product information management processes
6. Instructions on how to apply the concept in everyday business

The significance of building this kind of product information concept lies in the need to set common business rules for the entire corporation and its business and product areas. A carefully specified concept makes it possible to achieve synergies between businesses and between products. A common product information concept allows for the smooth and speedy implementation of PLM-related processes and practices because the most crucial areas of information have been agreed at common and conceptual levels.

A good PLM-concept is never static; it keeps evolving in tune with the business and its requirements.

Items

The development of product lifecycle management and the use of different product lifecycle management systems are very largely based on the use of items. An item is a systematic and standard way to identify, encode and name a product, a product element or module, a component, a material or a service. Items are also used to identify documents. What an item means depends upon the specific needs and products of each company. In addition to the above mentioned, such

things, as packing, installation tools, moulds, fasteners and software can also be items. The computer software used in production and the NC software for machine tools are often items. From the viewpoint of product lifecycle management, it is essential that items and their classification should be uniform within each company. It is essential also that items form separate classes, subclasses and groups at a suitable level of coarseness according to the company's own or, alternatively, wider international standards. In the electronics industry, for example, diodes might form a component class, with Zener diodes as a subclass. The clear and logical grouping of items into different classes eases the management and retrieval of individual items. On the other hand, an overly exact classification slows operational processes and considerably increases the amount of work required to maintain the items.

Items can be used in the intangibles (e.g. software or services) businesses in the same way as they are utilized in the manufacturing business. When utilizing a PLM-system to support the PLM processes the use of items is naturally required. In practice this means that the functions and features of a software or service must be transformed into items, i.e. encoded, named, and classified. The principles for making items out of service functions is discussed in more detail in chapter 9 – Service industry and PLM.

The structure of the item hierarchy must be documented, and the relations and hierarchies between items and item classes must be taken into consideration when creating an item-numbering scheme. This is referred to as an item hierarchy. National and international standards exist for the creation and unification of items in specific branches of industry. On the other hand, modern companies are widespread and even global entities. The sometimes include units of very different types, as well as bought and merged companies. There can be large differences in item fields and item coding schemes between the separate business units of these companies. A totally congruent and standardized encoding and numbering system is therefore not always the right or necessarily the best solution and a uniform corporate-wide coding scheme is not always something to work for.

Product data can also be controlled effectively without an entirely congruent field of items. Ready made solutions exist, based on cross-reference tables, which will tell you, for example, what name or code is used in Company B for item 1 in Company A. These tools can be used to integrate different marking systems and scattered item fields in large corporations. On the other hand, unifying the item world is an excellent way to integrate acquired companies and their operations at the level of daily business. The integration of companies becomes very apparent and concrete at a practical level from the use of common

items and a common item creation and numbering process. For this reason, the significance of items and a unified item base can be very important from the viewpoint of operations and cost efficiency. To achieve this requires an item management strategy because unification of large item bases can be very laborious and costly.

Product lifecycle management systems

A product lifecycle management or PLM system – what is usually meant by the term PLM – is ideally an information processing system or set of IT-systems that integrates the functions of the whole company. This integration is done through connecting, integrating and controlling the company's business processes and produced products by means of product data. At the practical level, the adoption of PLM is still too often restricted to only certain areas of certain business processes, such as product design and development. Kenneth McIntosh has proposed that PLM can be the operational frame of CIM (*Computer Integrated Manufacturing*) – one of the isms of industrial business. In other words, it is a system or set of systems, which integrate the functions of the whole company with the help of information technology. PLM is above all a connecting technology, not an individual technology islet or information processing system like a CAD (*Computer Aided Design*) system. A specialized IT-system can be very efficient in its own area but such systems usually cause bottlenecks elsewhere in the company's data flows and at the level of practical implementation in corporate IT-systems. The most important business processes, the product process and the order-delivery process, in manufacturing industry are cross-functional and cross-organizational.

The task of PLM, in one sense, is to provide the necessary conditions for connecting separate information data systems, processes and automation islets. Additionally, PLM should command a wide variety of information systems and thus give birth to integrated totalities. Commanding the totality of various processes brings considerable value to companies by seamlessly integrating information from organization-wide processes using different information processing systems.

Figure 2 illustrates the core processes of an industrial enterprise. It shows how the core processes are cross functional and cross organizational.

Figure 3 illustrates how a PLM system is positioned as a common and central databank within the field of operation of the process oriented manufacturing enterprise described in figure 2.

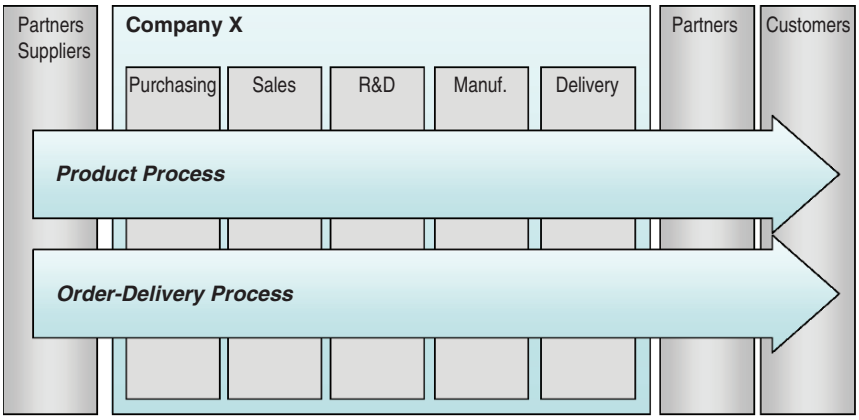

Figure 2. The core processes and functional verticals of an industrial enterprise.

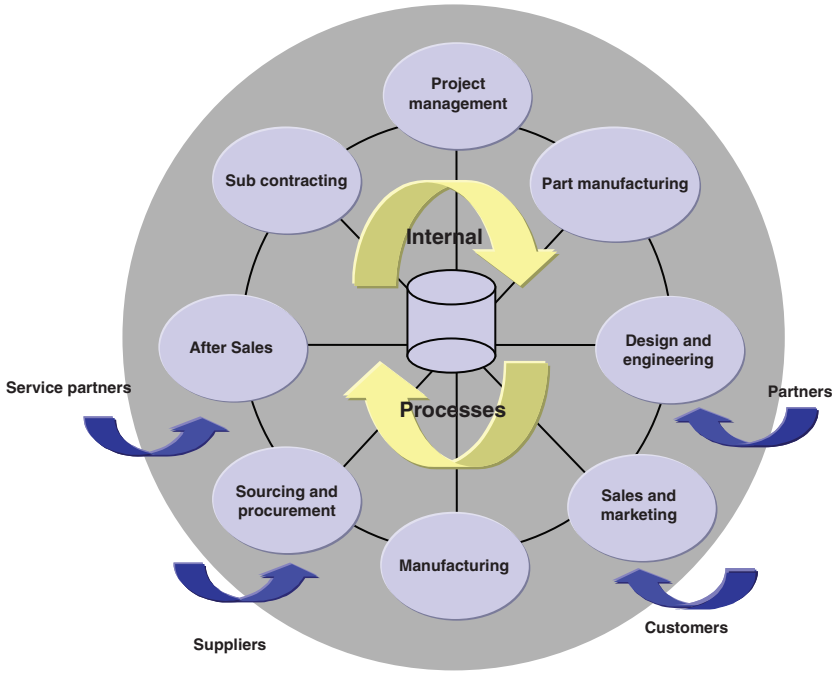

Figure 3. The PLM system often creates a wide totality of functions and properties with which to support the different processes involved in the creation, recording, updating, distribution, utilization, and retrieval of information.

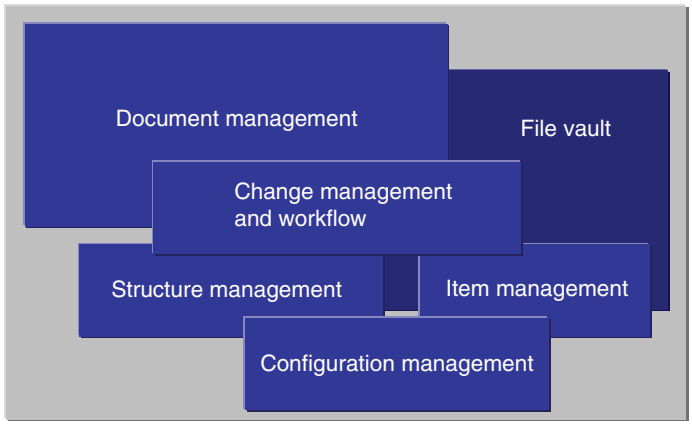

Figure 4. Product lifecycle management entities.

Typical features of such systems include (figure 4):

(a) Item management – one of the basic functions of a PLM system is the management of items. The system controls the information on the item and the status of the item as well as processes related to the creation and maintenance of items.

(b) Product structure management and maintenance – the PLM system identifies individual information and its connections to other pieces of information with the help of the product structure, which consists of items hierarchically connected together.

(c) User privilege management – the PLM system is used to define information access and maintenance rights. The PLM system defines the people who can create new information or make, check and accept changes, and those who are allowed only to view the information or documents in the system.

(d) Maintenance of the state or status of documents and items – the system maintains information about the state and version (e.g. sketch, draft, accepted, distributed, obsolete) of each document and item, and about changes made to them: what, when, and by whom.

(e) Information retrieval – one of the main tasks of a PLM system is information retrieval. PLM systems intensify and facilitate the retrieval of information so that: