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SYSTEMATIC APPROACH OF THE PRODUCT LIFECYCLE COMPONENTS

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Rezumat. *Astăzi, companiile din numeroase industrii se află pe punctul unei revoluţii în dezvoltarea produselor. Încorporarea soluțiilor software şi electronice în produse mecanice aduce un val de inovații, produsele devenind astfel sisteme inteligente, care sunt interactive, proactive, schimbătoare şi actualizabile. Atâta timp cât software-ul şi electronicele aduc atât de multă valoare noilor produse, marile companii au început să vadă şi să dezvolte produsele ca pe niște ansambluri. Companiile de top au trecut la o abordare sistematică care impune dezvoltarea componentelor mecanice, electronice şi software simultan încă de la stagiul de concept continuând pe tot parcursul ciclului de dezvoltare. Acest articol își propune să abordeze noua viziune a conceptului PLM pornind de la influențele aduse de evoluția internetului, procesul de globalizare pentru reducerea costurilor de fabricație și noilor tendințe de lucru colaborativ.*

Abstract. *Today, companies across numerous industries find themselves on the cusp of a product development revolution. The incorporation of software and electronics into mechanical-based products is driving a wave of new innovation as products become more like intelligent systems that are interactive, proactive, changeable and upgradable. With software and electronics driving so much new product value, leading companies have begun to view and develop their products as systems. Top companies take a systems-based approach that requires simultaneous and connected development to occur between software, electronics and mechanical functions at the earliest design stages and continue throughout the product development cycle. The purpose of this article is to address the new vision of the PLM concept starting from the impact that intelligent systems, internet, globalization and collaborative engineering brings.*

Keywords: Product Lifecycle Management, information management, product data management, concurrent engineering, design engineering

1. Introduction

Lots of the terms and acronyms that are in circulation today include words that are either vague or imply time dependence. For a term to gain acceptance and wide usage over a long period of time, it must be unambiguous and stable.

This article provides the new approach of PLM that clearly define the scope and the future of PLM.

The key aspect of defining the new approach of PLM 2.0, as is defined by Dassault Systemes, is the separation of the product information management from the information processing. The document also proposes that since the scope and

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role of PLM impacts every aspect of a business organization, it should be viewed in a completely different light to past technologies which, in the main, had a point solution focus.

From tens of new technologies that have emerged in recent years, only two can be said to have had a fundamental impact on PDM. The most important technology that evolved a lot is the Internet with its new web platforms that made possible for PDM users to access a system without the need for a ―physical link". The second allows that geometry and other product information can be reused by virtually all business processes downstream of the design process. This reuse provides an immense benefit through the elimination of non-value added activities, such as re-keying of data, enabling concurrent work as well as avoiding transcription and translation errors [1].

So the ground has been the impact of these two developments that they have led to a profound change to the way PDM, CAD/CAM and other computer aided technologies are developed and used. The increasing use of the same product definition outside the design office, led not only to tight coupling of related technologies such as CAD, CAM and CAE, but also to the convergence of other technologies notably CAx and PDM. The Internet, on the other hand put an end to any site location and geographical constraints. Thus, together these two developments made it possible, for the first time, to solve the emerging needs of businesses operating in the highly competitive, heavily outsourced, global environment. Namely enabling organizations to cut costs and time to market - through more effective use and reuse of resources, be nimble and quick to react to market changes - through the ability to focus on core business and increased collaboration with suppliers and partners, increase innovation - through better visibility of product data to all personnel both within the enterprise and extended enterprise.

Currently, with encryption technology to provide secure access across the Internet and a standard web browser as the user interface, it is possible for multi-disciplined teams to work concurrently on the same product data, from anywhere around the world.

Another significant side-effect of the Internet is the emergence of the web browser as the ―standard" user interface. This has provided consistency in the presentation and interaction with product data, making it easier for team members to communicate. The result is that project teams can include members from a wide range of disciplines, as well as include suppliers, partners, customers and other interested parties.

Many of the terms and acronyms tend to refer to what is being done (e.g. design, asset management); how it is done (e.g. collaborative, etc); or a vague reference to

the application area in which it is being done (e.g. eCommerce and eBusiness). Also, some vendors present a piece of technology as a total solution, when in fact they are simply offering a tool or application that addresses a specific application domain.

Some of the definitions given to the various terms and acronyms include long lists of benefits, and how the benefits are delivered. Confusion arises because processes and benefits vary from one company to another and from one industry sector to another. They also vary from one time to the next, depending on the key business drivers of the day. That may be bad enough, but when the word "Lifecycle" is introduced, the term can mean virtually anything. For something to be defined accurately, it needs to have a finite and identifiable scope. If the definition is to have any reasonable lifespan, it should not rely on the definition of anything that is time dependent, such as a process or benefit.

With this in mind the next section will introduce a new definition for PLM 2.0 that is valid today and stands a good chance of still being valid next year and in ten years' time.

2. New approach in PLM

International Journal of Product Lifecycle Management defines PLM „as a strategic business approach for effective management and use of corporate intellectual capital" [2]. This definition uses the term "intellectual capital" because this is what is being managed, and its use is what delivers the organization's objectives. This definition will apply to small, as well as large businesses; to profit making organizations, non-profit making organizations, as well as service providers. The corporate intellectual capital (CIC) was defined by Datamation [3] as consisting of the followings:

- Product and Process Definition: All the information relating to what the product (or service) is, its specification, how it is designed, manufactured, delivered and supported.
- Product History**:** Any information relating to what the organization has done in the past that is of relevance for the delivery of the organization's objectives, e.g. audit trails required for legal or regulatory purposes, archives relating to past products.
- Best Practice: Encapsulates experience gathered by the organization in the course of the delivery of its objectives.

The optimum way to manage each of these components varies from one organization to another. A PLM solution should therefore be assessed on its effectiveness in managing all three components through the product lifecycle.

CIMdata [4], an independent, global consulting company that has established itself as a world-leading source of information and guidance to both industrial organizations and suppliers of PLM technologies and services, defines PLM as „a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life—integrating people, processes, business systems, and information." PLM is an integrated, information-driven strategy that speeds the innovation and launch of successful products, built on a common platform that serves as a single repository of all product-related knowledge, data, and processes. PLM is the process of managing the whole life cycle of a product starting from generating an idea, concept description, business analyzes, product design and solution architecture, technical implementation and product testing, to the successful entrance to the market, service, maintenance and product improvement. PLM gathered and make accessible data and information of all stages of this process.

As a business strategy PLM captures best practices and lessons learned, creating a storehouse of valuable intellectual capital for systematic and repeatable re-use [5], [6], [7]. As an information technology strategy, PLM establishes a coherent data structure that enables real-time collaboration and data sharing among geographically distributed teams. PLM help companies consolidate multiple application systems while leveraging existing legacy investments during their useful lives. Through adherence to industry standards, PLM minimizes data translation issues while providing users with information access and process visibility at every stage of the product's life [6].

Another consulting company thinks PLM ~~–is~~ an all-encompassing approach for innovation, new product development and introduction (NPDI) and product information management from ideation to end of life. PLM Systems as an enabling technology for PLM integrate people, data, processes, and business systems and provide a product information backbone for companies and their extended enterprise."[8] For sure, PLM can be a corporate strategy, a way for a company to not only control costs but achieve revenue gains and they can also consider that to be a solution to some of the problems they are facing, some of the challenges that are happening.

Even though the core and the history of PLM is based in producing products and designing mechanical systems, PLM goes much more beyond just mechanical. And when we talk about the lifecycle, it is not just the cycle of getting a product from design to manufacturing; it goes well beyond that as well. And when we talk about managing product lifecycle as well goes beyond that same scope where Product Data Management (PDM) addresses engineering, management and information, PLM goes beyond that.

3. Concurrent Engineering and Product Lifecycle Components

Information management solutions for product development processes have evolved significantly since the beginning and have, as objective, the improvement of productivity (decreasing costs and product cycles increasing in the same time the quality of the product) as showed in Fig. 1. Software tools for mechanical design are increasing based on Concurrent Engineering (CE) and Product Lifecycle Management (PLM) as to assure transferability of the information between different members of a project, to improve the development process and to be quicker on the market.

Product Lifecycle Management enables the kind of convergence that Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) prompted in the past. In the early 90s, ERP unified finance, HR, manufacturing and warehouse systems. A decade later, CRM brought call centre and sales force automation together. Now, Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Product Data Management (PDM) and manufacturing process are converging through PLM. Yet PLM is unique from other enterprise software solutions because it focuses on driving top-line revenue from repeatable processes. Through PLM, the products are a path to innovation, industry leadership, and topline growth [5], [6].

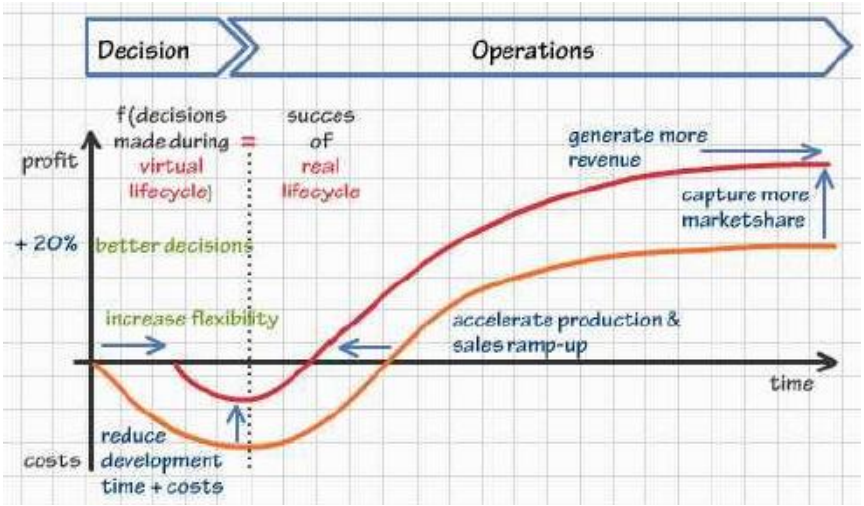

Fig. 1. PLM Impact on profitability [9]

3.1. PLM a requirement for Concurrent Engineering

Concurrent Engineering is an approach which allows taking simultaneously into consideration all stages of product lifecycle. This approach relies on sharing multidisciplinary information which allows reducing design mistakes and interactions, making change and react easier [10], [11], [12]. The designer should

be aware that the impacts of his choices are exponential throughout the development cycle. The costs of changes and the constraints due to specifications of the lifecycle (employed process, machinability, usability, etc.) oblige the designer to make the best choices early in the development process. So, it is necessary to increase the designer's awareness of his decision impacts on parameters like time to market, cost, quality, reliability, maintainability, recyclability and human factors. As a consequence, stakeholders require a tool that will inform them of their choices and their impacts on the various parameters of the product development [13]. Analysis of current manufacturing methods shows that information is the base of product development. Product lifecycle is a period which includes every step of the product life from the raw material extraction and the conceptual design to its own valorization and disposal [13]. It requires many tools, processes and technical skills, which thus involves information about many domains like design, manufacturing, marketing, sales, finance, etc. Product Lifecycle Management aims to create and share information between all stakeholders during the complete lifecycle, which facilitates communication between all the phases of the product development [14].

3.2. PLM Infrastructure

In order to optimize the product lifecycle, many authors have studied the domain of knowledge management for various fields. First centered on cost and delay decrease; afterwards based on quality, reliability and maintainability improvement [15]; and essentially based on sustainable development concepts [16], [17]. PLM solutions meld technology, methods, and best practices to address today are rapidly changing business environments. „PLM is a catalyst for change within a business – an opportunity to improve processes and organizational relationships to create an innovative measurably improved business." [18] It is important to note that PLM is not a definition of a piece, or pieces, of technology, it is a definition of a business approach to solve the problem of managing the complete set of product definition information – creating that information, managing it throughout its life, disseminating and using it throughout the lifecycle of a product. PLM is not just a technology, but is an approach in which processes are as important, or more important than data. It is critical to note that PLM is an concerned with ~~"h~~ow a business works" as with ~~"w~~hat is being created" [18].

The sustained improvement of Product Development Processes (PDPs) has long been the focus of manufacturing and more recently that of design as well. This is due in part to the key realization that a PDP constitutes not only a central component of the engineering effort but also a core business process [19]. As pointed out by Wheelwright and Clark [20], it is those firms that are able to develop and bring to market their products the fastest that are able to create a

significant competitive advantage for themselves. Efforts aimed at reducing product development times, however, are faced with several challenges, identified by Lu [21] as pertaining to increases in product complexity, increases in time-to-market (TTM) pressure, globalization and segmentation, and increasing customer demands. While a number of recent research activities focus on addressing the needs, underlying these challenges, a majority are aimed at meeting the intensive information requirements posed. PLM involves activities from the initial conception to retirement of the product and is aimed at improving the product development process. The goal in PLM is to integrate all the product realization activities including market planning, concept development, design, production, sales, marketing, etc. Considering the field's extensive scope there are numerous interpretations, each highlighting different facets of import. Examples include a) interoperability issues and standardization in CAD/CAM/CAE, b) overarching management considerations, c) collaboration, d) product information management and sharing, and e) integration of tools. In Fig. 2, we present three key components of an enterprise's intellectual capital – process information (top-left corner), product information (top-right corner) and the supporting PLM infrastructure (bottom) that consists of various software tools. Arrows between tools are used to represent flow of information among them. Dashed and solid lines are implemented to illustrate the fact that some of the links are more developed than others. As indicated in Fig. 2, most of the elements of an engineering enterprise's intellectual capital relate to the acquisition of information pertaining to either product or process and the tools for transforming this information. The infrastructure of PLM, as defined currently, centers on the integration of various software and associated hardware tools, ranging from CAD and analysis packages to PDM systems, etc., used for capturing and processing product information. To some extent, these tools are also employed for capturing information relating to the underlying design processes. In our opinion, PLM efforts thus far have been focused on integration and the improvement of interoperability. Although some of the relationships depicted by dashed and solid lines in figure below have been implemented successfully, it is our belief that the effective management of a product's lifecycle extends beyond ensuring the seamless flow of information between tools and requires a system based perspective of the entire engineering enterprise.

Although design processes play a crucial role in PLM, integrating the design of ~~"d~~esign processes" with the product has received little attention. Systematic methods for designing design processes have not been formalized. Additionally, while it is true that the potential of leveraging components of existing products towards developing new products has been exploited, the possibility of leveraging PLM sub-processes in new product realization scenarios is substantial. Thus, as an engineering enterprise becomes increasingly concerned with meeting the dynamic

requirements of a global marketplace, closer attention must be paid to the mechanisms underlying product development. Perhaps the most crucial of these mechanisms is the design process. In terms of the engineering enterprise, this translates to the need for a systematic means of development for original, adaptive, variant, and derivative products. Although much attention has been paid to addressing this issue from a product-centric perspective by exploiting the reusability and scalability of products through product platform and product family design, not much attention has been paid to an engineering enterprise's primary resource commitment – the design process and its design.

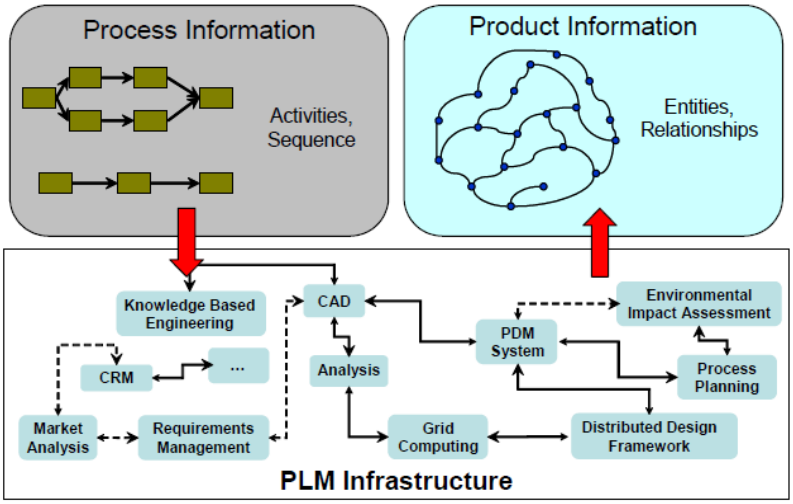

Fig. 2. Integrating Sources of Intellectual Capital in an Engineering Enterprise [20].

3.3. Product Lifecycle Components

CIMdata [18] defines the overall product lifecycle as comprised of three major, interacting lifecycle as showed in Fig. 3:

- Product Definition
- Product Production
- Operational Support

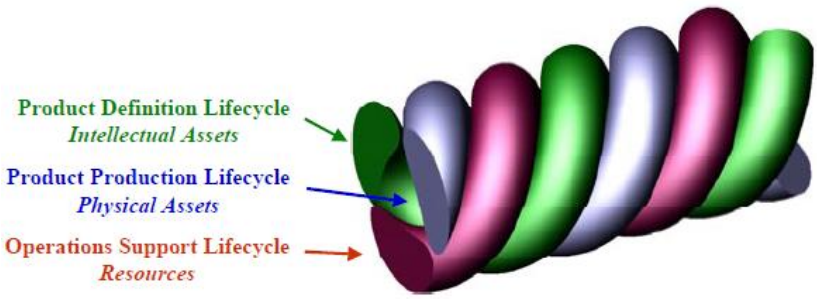

Fig. 3. Major Enterprise Lifecycles [18].

The product definition lifecycle (PDL) is defined by CIM data [18] as the creation and management of intellectual assets. As PLM, PDL starts at the earliest point of product idea and extends until the product is obsolete and the field support has ceased. Product definition is not just the upfront engineering design; it also includes the entire documentation that defines how the product was designed, manufactured, operated, etc. The PDL is an intellectual asset of a business that must be continually updated and must be created, captured, and leveraged through the company. Product Production (PPL) focuses on the deliverable product. This lifecycles includes all activities associated with production and distribution of the product. Enterprise Resource Planning systems are the applications that holds product production, focusing on how to produce, manufacture, handle inventory, and ship. The third major process is the operations support lifecycle (OSL) who focuses on managing the enterprise's core resources: its people, finances and other resources required to support the enterprise.

In any industrial company, the overall product lifecycle is composed of these primary and tightly intertwined processes. For an enterprise to succeed there must be close coordination and communication among all three lifecycles. A close and collaborative effort is required to create the seamless product lifecycle needed to bring innovative products to market effectively. The enterprise faces several challenges: developing an improved focus on product development and definition, learning to best capitalize on its intellectual assets, enabling integration among its people and organizations and create collaboration across the three lifecycles, effectively sharing product definition information throughout the extended enterprise throughout the life of the product or plant, seamlessly integrating with its suppliers to make them a logical extension of the enterprise for maximum collaboration and innovation. Management of the product definition lifecycle and its close integration with other major lifecycles is not a new concept. In fact, it has been around for many years. Over the last several years, industry's ability to achieve this concept has improved dramatically with the availability of a wide range of new technologies and approaches that facilitate collaborative work efforts across extended enterprises.

4. The Future of PLM

4.1. User perspective

The days of point solutions are fast disappearing. PLM makes product information more visible as a coherent whole rather than bits and pieces spread over a plethora of incompatible systems. Thus, PLM can lead to better and more informed decision making. The potential for cost cutting, improved productivity and innovation is immense. So is the potential for pitfalls since decisions and actions will affect more people than before. To get the best out of PLM, while avoiding

the pitfalls, requires a fundamental change to new business practices. A change where strategy is developed centrally on a corporate level, while at the same time giving users flexibility and freedom at the local level.

4.2. Market consolidation

As PDM technology evolved from being departmental solution (typically for the design office), to one offering enterprise/extended enterprise solution, the size of PDM projects became bigger. This process resulted in market consolidation where some of the minor players were acquired by bigger players who were better positioned to handle bigger and more complex projects. The emergence of PLM technology, has led to the acceleration of this process, both in terms of project size and in the size of mergers and acquisitions.

As PLM technology matures, it is expected that of the 10s of remaining vendors who provided PDM systems in the past, only 3-4 will become suppliers of core PLM technology. The remainder, who remain independent, will become providers of Business Applications. The most likely to make the 3-4 list of core PLM technology providers will be the current major players who also provide extensive CAx application suites.

4.3. Wider scope of PLM

For historical reasons, PDM systems catered in the main for the engineering sector. This is still largely the case with PLM. However, because of the generic nature of what core PLM functionality can offer, PLM use is beginning to expand beyond engineering to other sectors such as the telecoms, utilities and pharmaceutical sectors. It is expected therefore that new PLM solutions will appear for new business sectors and subsets of these sectors, Figure 4.

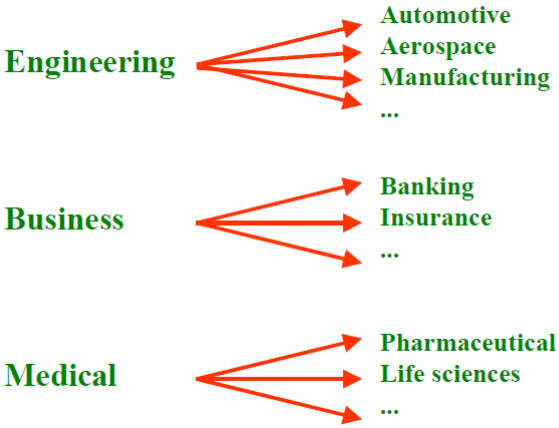

Fig. 4. System specialization for industry sectors and sub-sectors.

4.4. More innovation

Apart from the technological leap from PDM, PLM brings a new dimension to innovation. For the first time corporate intellectual capital is managed as an integral whole, rather than bits and pieces locked in different non-interoperable systems. In addition to the new breed of specialist software developers mentioned earlier in this section, there will be new groups of innovators who specialize in capturing best practice and turning it into reusable templates for creating next generation products. This will enable the invention of much better wheels rather than re-inventing old one!

Conclusions

The purpose of this work was to show the new approach of PLM and to review literature on PLM from an operational point of view with the objective to help companies to answer to the market requests.

In this paper, we establish that design processes are a critical factor in addressing lifecycle considerations of an evolving product portfolio.

Also we define the future trends and applicable market of Product Lifecycle Management.

With PLM and its role clearly defined, it would be much easier to estimate market sizes. Unlike in the past however, there will not be one market size figure, but a number of figures.

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