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Integrated Approach Bridging PLM, ERP, SCM in Automobile Industry

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Abstract. New Product Development (NDP) is a major source of competitive advantage to automobile manufacturers. More specifically, Product Lifecycle Management (PLM) has proven to have a positive impact on the effectiveness of the product development effort. One of the many reasons for that is the fact that PLM requires detailed attention to the constraints a firm will face, depending on the stage of the product. Widely accepted references outline the important of decision making in PLM. This trend is also is reinforced by the number of research projects in known, global centers of excellence in product development and innovation. Enterprise Resources Planning (ERP) approach is in the stake to supply the plan to best use of resources allocated to the project. Another revered trend is the idea of integrating the whole supply chain from a value-adding perspective. Thus, the Supply Chain Management (SCM) and Manufacturing Engineering Systemas (MES) of current and new suppliers for newly developed parts or products are the key players for the competitiveness in the market. Conversely, strategies, methodologies, and PLM tools present themselves as agile, lean, safe yet collaborative approach to NPD. This paper presents an integration of ERP into PLM with a special emphasis on SCM. The automobile industry, as an example is to contextualize the discussion.

Keywords. product lifecycle management, business process, supply chain, enterprise competitivenes.

Introduction

Presently, several technologies applied to the generation of information are available providing more knowledge and opportunities to the modern enterprises. Some of main emerging technology [1] Executive Information Systems (EIS), Decision Supporting System (DSS), Enterprise Resources Planning (ERP) e Operational Information System (OIS). The author complement that these are considered technology because some way utilize the computer resources of hardware, software, telecommunication system and the management of information data.

1. The development of systems MRP/ MRPII to ERP

One conception, [2] that the software MRP (Material Requirement Planning) initially when introduced in the market in 1960, contemplated only the production modules,

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purchase and stock management, with more prominence in the material needs. From the first module, other modules emerged and incorporated to the system such as: capacity requirement estimation, shop floor control, purchase control among others, reaching this way the first stage of the evolution of the MRP system that called MRPII (Manufacturing Resources Planning).

This evolution followed the technology improvement until to reach the stage of ERP (Enterprise Resources Planning), system introduced aiming to provide total integration of business solutions, linking more areas and functional sectors in several dimensions in the enterprise: human resource, financial costs, sales, purchase, logistics, among others, aiming to keep aiming to keep competitiveness advantage [3].

1.1. ERP systems: introductory aspects and overall vision of its benefits to the enterprises

Presently the Integrated Entrepreneurial Management System (IERP) reached expressive level mainly from decade of 90´. In the context of the development of the ERP system, [4] explain that, in decades of 40´ and 50´, labor cost represented 60 to 70% of the final costs of the product. By the decade of 90´, the cost of raw material represented 60 to 70% of the final products cost which does not match with the practice to keep large stocks.

Authors [2] the ERP system provides solutions that benefit and better the efficiency, quality and productivity of the enterprise, raising the results the satisfaction of the clients. In this context, it is noteworthy that, the utilization of the modules is linked to the type of business and the specific needs of the enterprise, although, those inherent to the finance sector are considerably more utilized (Table 1).

Table 1. Modules of the ERP, adapted from [5].

Modules related to Operations and Supply Chain	**Modules related to Finance/ Accountancy/Revenue Mgt.**	**Modules related to Human Resources Mgt.**
Forecasting and sales analysis; Bill of materials; Rough cut production/capacity plan; Materials planning; Detailed capacity planning; Purchase; Fabrication control; Stock control; Engineering; Physical distribution; Transport management; Projects management; Support the repetitive production; Support the mgt. of production in processes; Support the programming with finite capacity of discrete production; Configuration of products.	General accounting; Costs; Bills to pay; Bills to receive; Revenues; Revenue receipt; Revenue accounting; Cash management; Asset management; Orders management; Definition and management of the business processes.	Personnel; Payroll

Through, the integrated ERP system, the enterprise can improve the performance in the business to derive countless other benefits, which are presented in the Table 2.

Table 2. Tangible and intangible benefits of the ERP systems, adapted from [2].

Tangible benefits	Intangible benefits
Reduction of stocks	Visibility of information
Reduction of personel	New processes and improvement
Improvement in the productivity	More quick attendance to client
Improvement in the management of orders	Standardization
Improvement in finance	Flexibility
Reduction of costs	Globalization
Improvement in the management of cash flow	Better performance in the business as whole
Increase of the profit	
Reduction of costs with transport and logistics	
Reduction of costs of the maintenance	

1.2. Main characteristics of the ERP system, factors that interfere in the implantation and changes caused in the organization

In this context, authors [6] state that the implantation of ERP system causes impact of extraordinary repercussion in the enterprise, such as: changes in the management models, change in the interaction among persons and groups, redefinition of the limits of authority and autonomy e alteration in the strategic processes of the organization.

In several cases of implementation, these systems were considered unsuitable by not achieve with success the target of the enterprise [7]. In the acuity of this issue, denoted that several factors interfere to obtain the successful implantation to derive desired benefits, therefore, it becomes necessary more broad analysis of these facts. This way, a wholesome aspect to the system to achieve effectively the organizations objectives would ripening and the preparation of the enterprise for a change defining clearly the needs and business objectives, enabling persons to face the behavior and technological challenges.

Systems as commercial package: the suppliers of the software had put effort to link their systems to specific market niches. The difficulty for the enterprises consists on the adequacy of the software to business processes. Usually, ERP systems offered in the market as closed commercial package, obliging the buyer entrepreneur the adequacy to the software. Is denoted that this is the marketing strategy of ERP, whereby such systems are not developed for the specific clients, aiming to attend generic requirements of major possible number of entrepreneurs, right to exploit the gain of scale in its development" [8].

Total integration of the sectors: this is positive factor of these systems, once the information present unique input, generating consistency, efficiency, thus offering reliability to the managers. Adding, the integration of departments/divisions of the enterprise facilitates technological updating and the reduction of costs [9].

Functionality adequacy: the acquisition of ERP system can generate two situations to the enterprise: first is the process to adequate the system to the organizational needs through parametrization; second is the process of personalization or customization, which consists in the adaptation of the system to the specific needs of the enterprise. In this case, other programs also should be integrated to ERP;

High costs: this considered as the main factors that obstruct the implantation of ERP system. The costs predominantly related to the infrastructure of hardware and

software, consulting, training, contract of specialized personnel and other costs incurred in the change of the system. Likewise [10], declared that what denotes is the lack of planning, forecast the spending with customizations, that in consequence, end up generating costs that exceed the foreseen budget. Regarding to this fact, it appears that in several cases supplies do not offer support to the entrepreneur routine highly customized, competing equally to elevate the costs with the maintenance of the system [11].

Locating process: The ERP software developed in foreign countries can adequate to the reality of the host country. However, is crucial to analyze the risks and impacts of these changes. Corroborating this statement, authors [10] explained that the culture of the country and the government policies also influence the process of implementation, mainly when occur in different countries, thus affecting the configuration and maintenance of the software. Government policies, often imposes conditions that the software ERP is not adequate to solve the problem. The authors call this as "effects of the national culture" [10].

Updated version: offer the possibility of upgrades, that are improvements incorporated to the system, updating with new version to adequate the changes. This aspect has received critical of other authors, by claiming that there is difficulties in the flexibility of the system to adapt to the reality of the enterprise, to answer the variations and the growing of the business [12].

Alterations in the productive and administrative processes: this is the main of the system. The adaptation of the processes, so much productive, as well as administrative, aims to improve the relationship of enterprise with the system and vice-versa.

Impact over human resources: Given to the relevance of the human factor in the implantation of the ERP systems, it´s not possible to plan the system without considering the impact that will cause in the persons. More than the technological tool applied to better the work processes, the system calls the alteration in the profile of staff, requiring multidisciplinary knowledge and the predisposition to paradigm shift. Complementing, the author [4] states that the most difficult task is to integrate persons and different departments involved in the implementation of the system. This occurs because when deals with persons, normally exists the reaction behavior against the changes.

Difficulty to comply with the dead line and budgeting: This factor, according to authors [13] can occur due to the frequent change of personnel in the enterprise, lack of training, resistance to use the program, quality of the contracted consultancy, technical limitations of the system itself, and affinity of the ERP with other existing systems in the enterprise. There is still, other factors such as time, uncertainty, inadequacy to the needs of the users and the deficiency in the definition of functional requirements, that also cooperate to make difficult the implantation process [4].

Analyzing what presented towards ERP systems, denote that these systems present for the enterprises two opposite situations: first regarding to the benefits and impacts that cause; second the difficult of implantation. For that reason, the discussions towards investments, complexity of the system, functionality and adaptability outcrop increasingly in the enterprises.

2. Product lifecycle management for innovative and competitive business

Product lifecycle management (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 and technical implementation, to the successful entrance to the market, service, maintenance and product improvement.

At present, a wide range of stakeholders including consumers, regulators, shareholders and public bodies aredemanding that companies address product management through all life cycle in a more comprehensive and sustainable way. However, even if a company actually wishes innovate its processes for improving the way to account for project management, it will face relevant difficulties to deal with different guidelines, tools and methods currently addressing the matter from various points of view. The purpose of this paper is to review literature on PLM from an operational point of view with the objective to help companies to answer to the main market needs.

The goal here is to enable product development teams and manufacturing teams to work together as early in the product lifecycle as possible to: minimizing production cost, improving product quality, delivering more reliable products, providing easier to service products, driving "green" initiatives that facilitate a sustainable environment.

PLM 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 center and sales force automation together. Through PLM, the products are a path to innovation, industry leadership, and topline growth [14], [15] and [16].

2.1. Technical requirements

Due to cost pressure, producers are forced to standardize and introduce standard components. The extended time in use of plants, along with the usage of standard components, requires adapted lifecycle management strategies. As a result, there are high compatibility requirements such as service requirements.

Because of the short times in use, producers of automation components traditionally offered standard services. However, because the times in use are increasing, producers of automation components can now offer continuous service extending over a number of years. The re-use of systems at other locations, or in manufacturing facilities for new models, applies to all automation components, including systems such as robots. Additionally, a number of producers offer refurbishment and reprocessing of used products as a service.

2.2. Industry-specific economic aspects

In automobile manufacturing, the initial investment for a plant or a production line is the financial focal point. However, the life-cycle-costs are becoming increasingly important in the planning phase. This also leads to employee-related cost savings due to the capability to deploy employees across different plants. Additionally, standard components can typically be sourced more quickly from manufacturers.

Previously, different variants of a specific vehicle model were manufactured on several production lines. Presently, however, these variants are produced on only one

single manufacturing line. As a result, automobile manufacturing is now characterized by very flexible manufacturing processes and high throughput rates. Another cost saving option is the use of modular- and platform-concepts.

The fact that these platforms are used for multiple applications ensures better manufacturing capacity utilization and thereby lower production costs. When considering costs, investments in modernization are assessed in comparison to the increasing life-cycle-costs of the existing system. The reuse of systems can lead to reductions of investment costs of up to 40 % [17].

Cost savings achieved by increasing energy efficiency and the conservation of resources such as gas, water and electrical energy are topics that are increasingly high on today's agendas. Under the heading of "intelligent load management for plant sections" improvements in energy efficiency are addressed. One such option is completely shutting down plant sections when they are not required.

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.

In the current economic climate, addressing global business challenges is the top priority of most medium and large enterprises. Whether they want to expand their customer base in new markets, or to leverage more cost competitive resources, conducting their business globally is a necessity [15]. To sustain an advantage, they have to overcome the challenges of a dispersed organization, while still empowering individual team members to excel.

PLM concept offers comprehensive solutions to help enterprises address their challenges and create competitive advantage. Five areas where medium and large enterprise should have achieved success include: Managing new product introduction, to create a winning product portfolio; Achieving concurrent engineering globally, to be faster to market; Creating platforms for reuse, to reduce cost and speed product customization; Managing product and manufacturing complexity; Supporting products currently in-service, to ensure they are available for use at minimum cost.

2.3. PLM metrics development process

The questions often asked in business and commerce are how well are done, and how do know what the work should be done? Find out the metrics process to measure what is meaningful is important in this issue [16]. The way to find out answers to these questions is to measure the outcomes of the processes involved. As PLM transforms the way enterprises do business, it is important to understand how well they are doing currently that need to be measured. The measurement of PLM requires the development of metrics for the process which is essential that what is identified as a metric is relevant, appropriate and important. The metrics can be applied at various levels of complexity as the objective of the metrics development process is to identify, develop, and articulate metrics that would help enterprises implementing PLM determine the extent to which their efforts are paying off. The PLM assessment process model shown at the Figure 1, conceptually presents the metrics development process.

Level 1: At this level, the question is whether the enterprise is applying appropriate resources to the PLM process;

Level 2: The metrics are used to determine if the appropriate PLM processes were implemented;

Level 3: Focuses on customers being reached;

Level 4: Metrics to examine the efficiency whether the outputs meet the needs of customers are being met;

Level 5: Effectiveness, if desirable results are being achieved;

Level 6: Metrics are used to measure the impact of the implementation of PLM by measuring the extent to which procedures and controls have been integrated and the return on investment. This level metrics are the most complex and difficult to measure. These include waste reduction, innovation or new products, continuous improvement, and sustainable green manufacturing.

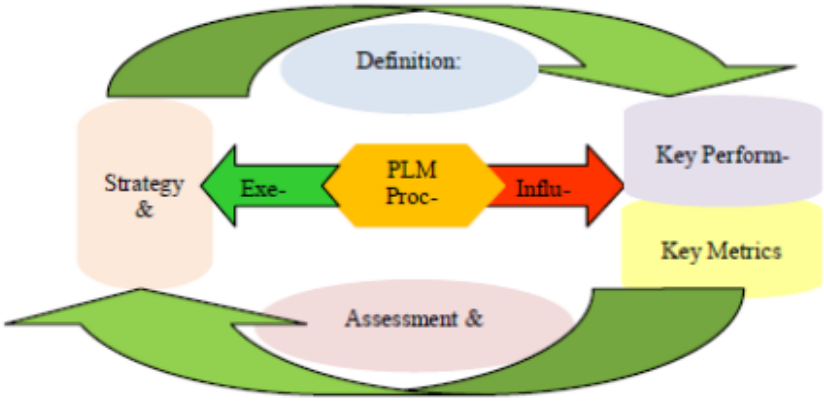

Figure 1. PLM Assessment Process Model [18]

2.4. PLM business value

PLM business value is perceivable when the enterprise implements this concept in work that can move forward strategically while achieving sound results and enable to establish a platform for innovation. When the enterprise addresses specific business issues to build a solid foundation for future success through PLM platform, it will be able to realize measurable innovation benefits both immediately and over the long term as can be seen on the Figure 2.

Traditionally the business practice by enterprises is to bring their products to market in time-consuming serial processes that delayed the participation of downstream contributors. The participation of suppliers, manufacturing experts and after sale service or maintenance providers were aside. PLM enables to allow the enterprise to execute as many tasks as possible in parallel processes to streamline and collapse critical stages in the product lifecycle.

Furthermore, the PLM allows to deliver aligned and accurately highly synchronized product knowledge to multiple disciplines early in product lifecycle. Avoids the cost and scheduling impact that comes when late suggestions and unexpected concerns arise from downstream players. It enables the enterprise to beat

the competition launching the innovative product content that carries advantages and drives early sales for profit.

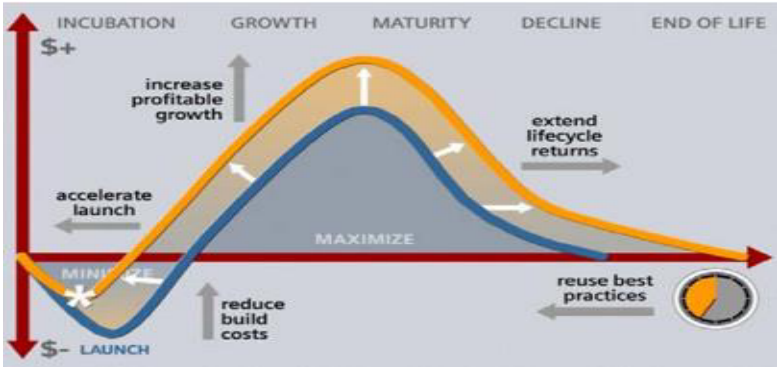

Figure 2. PLM business value [18].

2.5. Increase profitable growth

In the world class manufacturing scenario the cross-functional teams collaborate in real time on the development process, each contributing their unique experience and perspective for quality and cost effectiveness.

Lessons learned and the knowledge acquired are captured for potential re-use in a process of continual innovation, facilitating the mass customization delivering the product offerings that satisfy the needs of individual customers and targeted market segments. It combines the advantages of configuration of option and variant management. These capabilities allow the enterprise to perform portfolio planning in as flexible and continuous process as possible to fulfill the customer requirements.

2.6. Integrating enterprise solutions

Understanding the value and function of key technologies and how they interface each other flowing smoothly is a matter how the stakeholders enterprises are structured using updated information technlogy effectively. Supply chain management practices are paramount to connect either in house or outsource manufacturing engineering systems. The ERP, as a transaction driven sector, all involved sectors should operate synchronized way to avoid any interruption in the communication system. Likewise, the PLM sector is composed by the driven sector, so that must be provided by a buffer of information concerned modern product development process, manufacturing and portfolio management process. The SCM and the MES are the event driven sectors, such that must guarantee the real time data collection, quality reliability, logistics and delivery.

2.7. Work package generation

PLM as new approach provides a single source of truth of intellectual property, thus production planners have work packages that contain all necessary information including but not limited to: bill of material information, electronically validated process steps, associated resources, and equipment list.

To maximize efficiency and the enterprise performance by leveraging the relationship and data flow throughout between PLM, MES and ERP, those approaches are integrated as shown in the Figure 3.

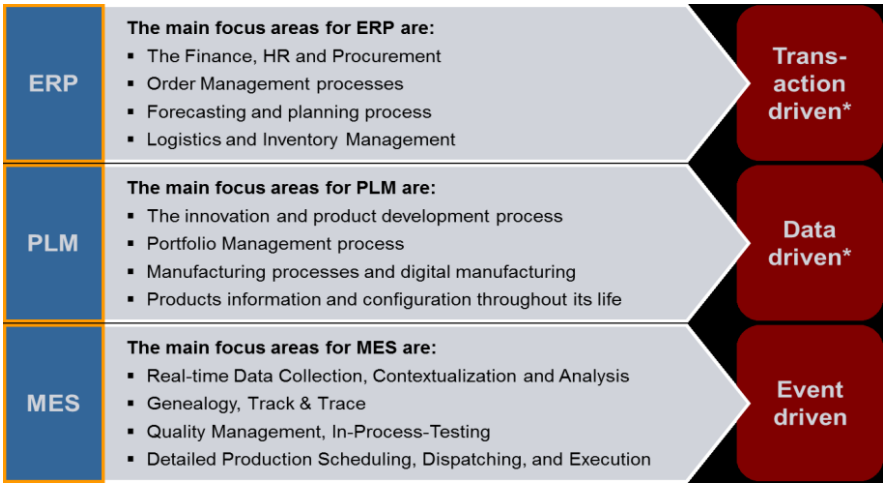

Figure 3. Integrating enterprise solutions [19].

By implementing enterprise information systems to develop more efficient facilities and adopt new, innovative ways to capture and execute manufacturing and maintenance contracts, the PLM provides a comprehensive collaboration foundation by the closed loop PLM-MES-ERP and by the adoption of technology to support an integrated business approach to improve the communication tasks accurately.

3. Why is PLM a necessity in automotive industry?

Reasons why is PLM a necessity in automotive industry can have several answers:

There are always many new products being developed simultaneously in the automotive industry with large number of designs being created, reviewed, modified and approved [20].

Due to the competitive nature of the automotive sector, the products have to excel in terms of quality, cost and usability. Ability to quick customization of automobile features is an essential part of the business practice as the smallest error can mean a huge production, capital and brand image loss.

Proper coordination between the designers, engineers and production units in the assembly line is a must as the collaboration across the enterprise helps catch the errors and rectify at the designing phase itself. This saves the cost and effort of repetitive manufacture of defective parts.

4. Consclusion

Competitive advantage to automobile manufacturers is alwais dependent on new product development as a majojor source. Product lifecycle management has proven to have a positive impact on the effectiveness of the product development effort.

To achieve a successful enterprise endeavour the ERP approach is in the stake to supply the plan the best use of resources allocated to the project.

The value adding perspective of whole supply chain management and manufacturing engineering systems for newly developed parts are the key players for the competitiveness.

This paper presented an integration of ERP into PLM with a special emphasis on SCM and MES. The automobile industry, as an example is to contextualize the discussion for further studies.

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