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The Challenges of Adopting PLM Tools Involving Diversified Technologies in the Automotive Supply Chain

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Abstract. In order to reduce product development (PD) costs and duration, PD cycles are being accelerated in order to reduce the time to market and satisfy the end customer needs. Another key challenge in PD today, is product diversification in the technologies used, requiring improved collaboration amongst local and dispersed multi disciple PD teams. A main stream tool that aids and support engineers in PD to collaborate and share information / knowledge is Product Lifecycle Management (PLM). This research explores the benefits and requirements of implementing a PLM system for a PD and manufacturing company within the automotive supply chain. This paper first provides a brief background of the subject area, followed by an explanation of the initial industrial investigation for the implementation of a PLM system, from which investigation the resulting conclusions and recommendations are presented as the building blocks of the implementation project.

Keywords: Product Lifecycle Management, Product Development, Automotive Supply Chain.

1 Introduction

In today's fast moving engineering environment, accelerating product development (PD) is becoming the normal practice, in order to reduce the time to market, improve the quality, reduce costs and getting the PD process right the first time. Another critical challenge in PD today, is the required diversification in technologies used in the products and the way they are designed and manufactured. The main challenge to address these issues is to timely find PD information and reuse design information from past PD projects. There is also the challenge to improve collaboration between dispersed product development teams where companies form temporary partnerships in order to pool their mutual skills [1, 2], and engage with external engineering experts and institutes, forming dispersed PD teams.

A main stream tool that aids and support engineers in PD to collaborate and share information / knowledge is Product Lifecycle Management (PLM). PLM is defined 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 - improving product quality, time-to-market and costs [3, 4]. While PLM tools are generally believed are for big OEM companies a lot of attentions from the PLM developers is now being addressed to smaller companies within the supply chain.

This research explores the benefits and requirements of implementing a PLM system for a PD and manufacturing company within the automotive supply chain, to improve the visibility and the information management of the various PD projects, in order to facilitate decision making and reduce the inefficiencies that lack of visibility and fragmented information bring with them. An extensive investigation has been conducted within a global industrial partner to explore their needs and requirements. Arising from the investigation are the identified main benefits and the recommended building blocks to implement such a system. This paper first provides a background of the subject area; this is followed by an explanation of the initial industrial investigation, from which the resulting conclusions and recommendations are presented and analysed.

2 Challenges in New Product Development

In business and engineering, New Product Development (NPD) refers to the development of a new product which is launched in the market place. Innovation and NPD are critical to the success and sustainable competitiveness of manufacturing enterprises. NPD projects require different engineering disciplines such as Design and Product Development (PD), Manufacturing Engineering and Electrical and Electronics engineers to combine and collaborate their efforts in order to achieve agreed goals [5].

A successful product is typically determined by five factors: good quality, low production cost, short development time, low development cost and effective development capability [6]. These key factors are normally managed by different departments or groups, such as R&D, testing, marketing, sales and finance within an organization. The success of a product may only be achieved if these departments and groups cooperate and work together in harmony to achieve the end NPD goal.

The effective management of communication, information and knowledge sharing activities in local or global NPD teams, between different departments like design, purchasing and testing, requires sensitivity to the uniqueness of product development. The capabilities of multiple types of communication mechanisms and an understanding of which of these mechanisms best meet a team's needs for information and knowledge dissemination is a huge undertaking [7, 8].

Getting communication right between the different NPD teams and re-using the knowledge that already exists within a company can determine whether a new product is launched on time and/or on budget. Recreating and re-collecting the same knowledge for different projects is both costly and time consuming, which shows the importance of capturing and managing pre-existing information and knowledge already available among employees, so that further knowledge can be built upon it, which constitutes innovation in your PD process.

NPD project should be carried out by a core team with extended team members. The core team normally consists of key people, such as team leaders and engineers from different disciplines, while the extended team members include the support personnel that aid the core team with the relevant knowledge and resources required for a project. A NPD core team will drive the project through different NPD phases in order to achieve their goal. The first phase is planning of the project which is followed by concept development, this then moves onto system level design and detail design, once the first sample is constructed this goes to the testing and refinement phase so that the final product can be finalized. Once the product is finalized the final NPD process is the production ramp up so that products can be distributed to the market place [9]. These NPD phases are the ideal theoretical development cycle, but as all things on this earth nothing is perfect.

Communication amongst NPD team members is another important factor that can directly influence the success of a NPD project. With the implementation of having a core team and extended members within a product development team brings to the table new problems. In global organizations these core teams and extended team members can be located at different offices within the same site or at different sites with the additional complication of having different time zones which further complicate people's availability, which only emphasize the fact that team member need to stay on top of communication and control it. Communication in project management comes in many shapes and forms, such as oral communication, meetings, telephone calls, emails, documents, specifications, instant messenger systems, teleconference calls, and video conference calls [10].

Communication plays a crucial role in information & knowledge sharing and the social dynamics of a team. Without adequate communication channels, the team would fail to produce new innovative ideas that could be transformed into new products [11, 12]. Therefore, the combination of effective communication, project management and knowledge management are critical to the success of NPD projects.

3 Benefits and Issues of Product Lifecycle Management

PLM emerged in the early twenty-first century to manage the knowledge intensive process consisting mainly of market analysis, product design and process development, product manufacturing, product distribution, product in use, post-sale service, and product recycling. As its name implies, PLM enables companies to manage their products across their lifecycles [13]. PLM is of great significance as it can improve the development of new products and reduce manufacturing costs by controlling the products through their lifecycle [14].

PLM expands Product Data Management's (PDM) scope to provide more product-related information to the extended enterprise. Product Data Management has been developed to improve the management of data and documented knowledge for the design of new products and focus on the design and production phases of a product [15].

Figure 1. PLM Defining Elements

Table 1. PLM Phases[16]

Phase	Description
1. Conceive	Information is gathered from the marketplace, customer requirements are determined and the product is imagined and technical specifications based on this information are created.
2. Design	The product's initial design is created, refined, tested and validated using tools such as CAD. This step involves a number of engineering disciplines including mechanical, electrical, electronic and software (embedded), as well as domain specific expertise i.e., automotive engineering.
3. Realize	At this stage, the product design is complete and the manufacturing method is determined, with this phase addressing tool design, analysis, simulation, and ergonomic analysis.
4. Service	In this final phase of the product lifecycle, we enter the service phase, which may involve repair and maintenance, waste management and end of life (disposal, destruction) of the product.

The management path of PD within PLM addresses the general product engineering process from the creation of a product idea to its delivery consisting of dedicated phases, incorporating workflows and link components to each other providing a complete picture of the product definition. Typical phases of the PD process within PLM is defined in the table below.

Modern PLM systems are about sharing data instead of documents. Sharing data means information from documents is decomposed in pieces of information (metadata), in a database. Parts, related designs (3D models and drawings), Suppliers but also Tasks, Issues, Workflow processes and Requirements are handled in a connected database. This approach of integrated product data and document management has a massive advantage over a document-centric or a pure data centric approach as on-line status information becomes available for decision support and analysis providing the perfect balance for rigid and flexible data to be easily stored and shared. Figure 2 below shows the PLM architecture comparison of different data models.

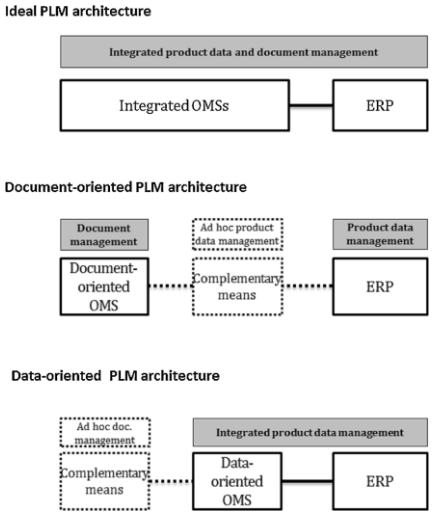

Figure 2. PLM Architecture Comparison [17]

The benefits of implementing PLM systems is being driven by both internal and external needs; the internal needs are to improve the efficiency of innovation process and to speed up the innovation as well as improve or enable network collaboration [18], while the external needs come from increasing the use of PLM due to the globalization and competition which often lead to distributed cooperative product development, in order to save costs or gain access to resources, competencies and markets [19].

The critical component to enable this is the centralized single version of the truth that the PLM infrastructure provides so that the business can response more swiftly and decide on PD decisions correctly the first time because the required full and up-to-date information is available for them to use. This centralization of information is also crucial to support global PD operations by enabling live information updates communicated to stakeholders immediately when they become available for the whole team to consume and take decisions up on.

PLM also enables and supports engineers, the PLM users by providing up to date information across the PD lifecycle providing shared access and linked data greatly improving personal productivity in developing new products, re-using readily available information and communication amongst the PD team.

An important aspect of implementing PLM processes and tools is the cultural change required for the team to embrace. PLM enables collaboration but the users need to accept that collaboration requires them to work differently in handling information and knowledge because they are not working on a department level but intercompany along the PD chain which in some cases can involve global team members. Work done by users will have downstream benefits and later upstream benefits, for which PLM users need to be motivated for. The target is to convince the business and the users that the decision for a new practice requesting organizational change is required and works. Only then the organization can enable the full potential of the PLM methodology without remaining stuck in the current practice [20], which brings the required cultural change and system acceptance.

4 Industrial Investigation

An extensive industrial investigation was carried out with an industrial partner using multiple methods. The industrial partner is a global developer of costumed engineered products and solutions with manufacturing, design and testing facilities in several countries around the world. The main purpose of this investigate is to identify a tool that is able to support product development processes for the immediate and long term future, with the proposed solutions being faster and more efficient than the current environment, while also being scalable and future oriented. The methods chosen for this investigation included;

- Analysing current process going though PD quality manual,
- Investigative workshops with stakeholders,
- One on one interviews with key personnel and process owners, and
- Process walkthroughs.

The PD quality manual, consisted of a list of all the PD processes and relevant documentation describing procedures that need to be carried out during the entire PD cycle. All of these procedures where analysed, listed and ranked according to importance and impact towards PD as potential candidates for PLM implementation. s

A considerable number of workshops with stakeholders were held in order to identify the benefits, PLM tools would bring to the business and highlight potential show stopper that current processes might bring with them. The stakeholders team consisted of two members from each and every department from the industrial partner. With one member being a seasoned person with multiple years of experience, while the second member from each department was recently joined with 1 year of experience. The purpose of this was to have a mix of opinions to balance out people set in there way with people with fresh ideas. This provided an extensive picture of current processes.

The one on one interviews were carried out with key personnel and process owners providing and extended understanding that was provided from the workshops. The interviews were carried out utilizing a structured questionnaire in order to obtain a consistent and balanced result from all the key personnel. While the final investigative method that of process walkthrough provided the researcher the opportunity to better understand each and every process and the possibility to question and challenge current thinking.

This investigation explored the benefits and requirements of implementing a PLM system for a PD and manufacturing company within the automotive supply chain, to improve the visibility and the information management of the various PD projects, in order to facilitate decision making and reduce the inefficiencies that lack of visibility and fragmented information bring with them.

4.1 Investigation Findings

The industrial partner worldwide employs over 6,000 people to serve a diversified group of customers in four market areas with automotive OEMs companies being their primary client base.

While extensive robust processes and procedures are already in place to support the PD process, it is heavily depended on a document-centric approach spread on over 150 IT systems, managing drawings, documents, product specifications, scheduling and ordering process to name a few. With their main PD file sharing storage area containing over 650,000 excel sheets, excluding documents on personal user laptops, and 1.4 million emails all containing vital PD information which is not revision controlled, easily searchable and could also be replicated in multiple locations creating the risk of out of date or obsolete information.

The current situation with information stored in different locations, with different interpretations lead to a complex environment in which an employee has to work. Highly experienced persons know where to find the proper information and how to interpret the data, although this is becoming harder over time. The lack of visibility and locked data are the main causes for inefficiencies, that could lead to fragmented information. The search ability and reusability of the information is also becoming an issue, and the larger the amount of disconnected data you have to search through the less likely users will re-use readily available data, that apart from data generation has a considerable impact on product development cost when the visibility to re-use parts for multiple project come into play. This situation increases the risk of taking the wrong decisions due to the use of wrong information, which leads to waste and mistakes. Which can have negative repercussions for the company from a financial, quality and reputation aspect.

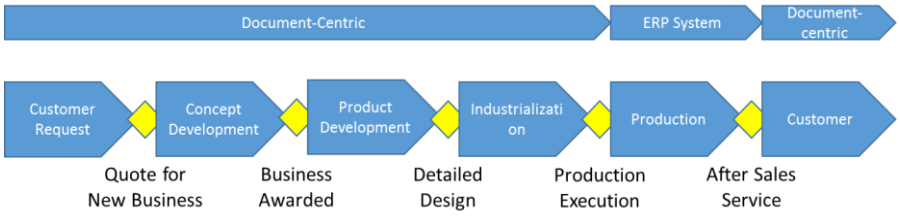

Figure 3. PD Process Flow

The PD process follows the traditional path along the PD lifecycle shown in Figure 3. The process is heavily document-centric with the only data-centric system along the lifecycle being the ERP system used for the production execution, but is completely disconnected from the product definition that takes place during the PD process.

The other clear observation throughout the PD process from the initial stages of quoting for new business right up to product servicing at the customer is bill of material (BOM) of the actual product, this is constant at each and every stage along the lifecycle implementing an integrated enterprise BOM system. The implementation should start around the BOM definition and can be expanded from there in different directions.

4.2 W/Shop findings

The conducted w/shops involved participants from various departments covering the whole PD lifecycle from sale, engineering, project management right to operations staff. The stakeholders involved had different educational levels and positions within the organization of the industrial partner, this provided an extensive picture of the current PD processes in order to identify the existing gaps and the potential benefits PLM process and tools might provide. The main identified gaps of the current process were:

- *Improved linkage of PD information.* It is important to visually and physically access information which is linked to one another. A typical example identified was that of a component inside a BOM that will provide the user the accessibility to all related information pertaining to it as in drawings, manufacturing definition, purchasing and supplier quotes, etc while also providing the links to the rest of the product both up and down stream providing the how product picture that is easily visualisable and understandable for the user.
- *Enhanced search ability of project / product information*. The disconnected information and multiple systems provide a massive issue to understand product and project definition. Engineering PD development project are executed over a long period of time, in the case of the industrial partner concept creation to start of production can take anywhere from 1 – 2 years of development. And in that time period the amount for data, information and knowledge generated is substantially large that is sometime with the best storage practices is hard to manage and retrieve especially if you are taking into consideration an older project. The importance of searching through Terabytes of information and within documents is vital tool to have in the future.
- *Better information reuse.* The reinventing the wheel situation, is a time consuming and costly process, when you consider that possible solutions are already available in the history of your previous product or projects.
- *BOM handling across the organization during the product lifetime.* Disconnected BOMs between departments creates the risk of errors and departments which are working with out of date information. The enterprise BOM would provide the structure and opportunity to communicate product definitions throughout the organization through shared data as a means of communication during product development. BOMs have been used for product design, production planning, procurement and maintenance as they contain the part list of a subassembly or assembly product. BOM currently plays a key role in the PLM environment because it is an essential product information platform in the industry [21].
- *Better link of project execution.* Similar to the first point of linking information the same was identified for project execution. The importance of providing status, information to team members, improved support of task execution and deliverables management providing a live and up-to-date picture of the project.

5 Conclusions

Implementing PLM has brought considerable benefits to other manufacturing companies. However, in parallel there is also the understanding that implementing PLM systems requires both the business and IT professionals to work together with equal priority to establish the PLM vision and system. The central vision supported by PLM is creating visibility for the whole organization and if needed the entire ecosystem to all product-related information in all phases of the product lifecycle. PLM provides information support not only in the bid or design phase but also provides support to the manufacturing planning and execution phase. Providing an environment where people share data, instead of owning data. A well-implemented PLM environment leads at the end to a "single version of the truth" for all product related information.

The investigation carried out provided real evidence for the industrial partner, highlighting the real tangible benefits that such a change to the organization can bring with it. Enhancing the linkage, search ability and improved BOM management of PD data provide a real tangible improvement that can have a significant cost reduction impact to the whole PD cycle, while also reducing the development time and therefore the time to market for NPD. These improvements would result in improved profits for the organization or more business by becoming more competitive. The improvements are not solely internal but throughout the supply chain, better control of information flow would bring benefits to the industrial partner's suppliers and customers effecting the entire supply chain.

The investigation has also highlight the feasibility of implementing such systems and provided a better understanding for the business where to go from here. PLM software's are vast complex systems that provide extensive tools and functionality for PD, it is not a plug and play package. Before implementing or even selecting a PLM tool, a business need to properly analyse and understand what their internal capabilities process before even thinking of implementing such tools

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