
A conceptual framework to develop assessment models for PLM implementation projects

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Abstract: The adoption of a PLM-oriented approach in large companies, or in a complex supply chain, needs a well-structured plan of change management. Product-Lifecycle-Management may significantly increase the efficiency and effectiveness of enterprise processes but requires cooperation between different actors and product-data information sharing; such interoperability often requires the evolution of organization aspects. This paper aims at presenting a conceptual framework that can support a large company, or a group of companies, in defining the assessment principles on which a PLM implementation project should be based on. Indeed, in the initial stage of a transition to a PLM vision, the process of gathering information assumes a key role in the creation of the knowledge base about the as-is state, specifically with regard to the company awareness of PLM concepts, to the adopted technologies, to the purpose of the project, to any specific requirement, etc. The framework presented here originates from the analysis of the common path towards the implementation of PLM logics at a corporate level by a large group of companies operating in the aerospace & defense industry.

Keywords: product lifecycle management; assessment; standard reference framework; corporate strategy

1 Introduction

Large companies that intend to cooperate with their suppliers/customers in designing, implementing and managing the product through its life cycle need an effective way to adapt their management perspective: an organizational evolution of the company is the necessary requirement to achieve a perfect coordination of begin, middle and end-of-life activities management, i.e. from design, through production, logistics, product support, up to the reuse or disposal of products. Once the benefits on PLM of this new organizational perspective are identified, a series of actions should be undertaken in order to promptly identify the areas of intervention and provide a roadmap for managing the change in the entire company. This evolution should be, however, based on specific guidelines: these can hardly be defined *a priori* and their definition requires the participation of several figures of the organization. The industrial case that inspired the work which is partially described in this paper is related to a large group of companies, operating in the aerospace & defense industry, that agreed on cooperating in defining a common path towards the implementation of PLM logics at corporate level.

2 A standard reference framework as a guideline to start PLM projects in a group of companies

A PLM implementation project needs a strategic commitment to create those favorable conditions to enable the progress of the implementation phases of the project through an initial top-down approach.

When dealing with a group of companies heading towards a PLM vision at a corporate level, a prerequisite for generating a significant participation of the different entities is, surely, an effective management capability, in order to lead the corporations, with motivation, toward a path of change. A strategic commitment can be reached, for example, by creating focus groups coordinated at a central level and composed of the most credited representatives of the companies involved on the PLM project. On top of allowing members to interact and share experiences and solutions, focus groups keep a bottom-up approach and force each entity to be practically involved at least in the first step of the scenario definition. The first outcome of a PLM transition project, at corporate level, should certainly be the definition of guidelines to be used by each company to start specific PLM projects. To this extent, an assessment phase may conveniently represent the initial step in order to define a framework structure, collect all the basic information and create a macro-scenario.

In this sense, three aspects should be considered and properly balanced in order to design an effective development path:

- **Technological issues:** include aspects related to infrastructures, applications and data exchange standards that allow interoperability with customers/suppliers. These elements, often rated as major factors for the success of a PLM project, should however be analyzed coherently with the other elements.
- **Organizational issues:** represent all the elements related to the organization (business processes, roles, involved professionals, etc.), which typically are the most complex aspects to cope with, given the natural attitude of organizations to maintain their *status quo*.

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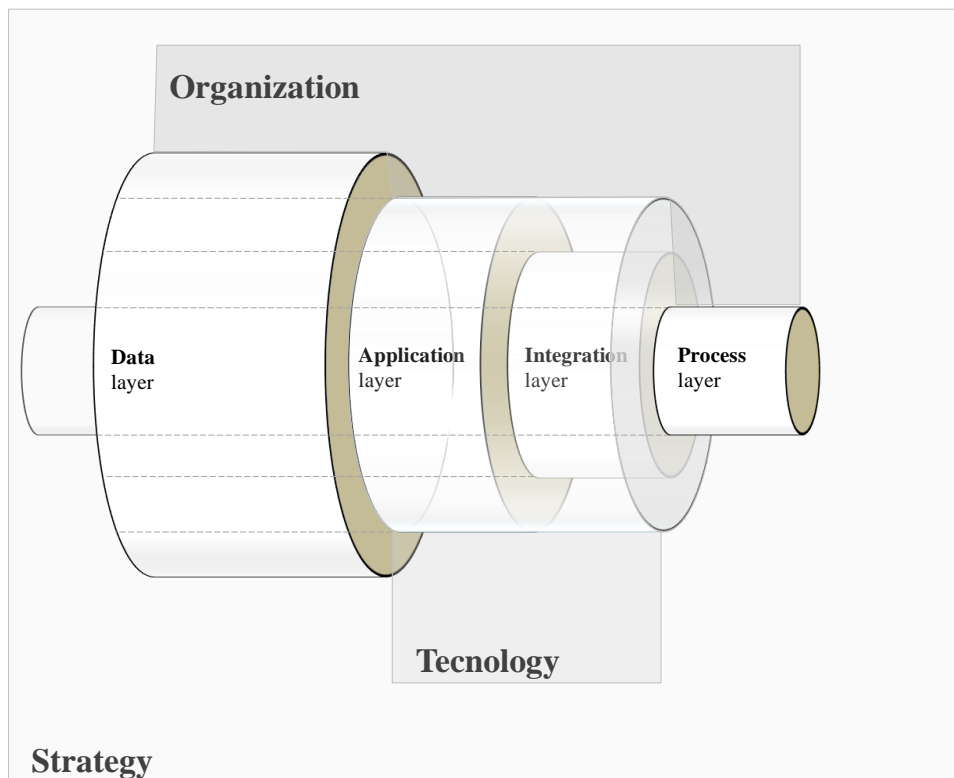
- **Strategic issues:** include the definition of the intervention strategies, budget, benefits, risks and SWOT analyses associated with PLM projects, etc. which allow translating plans into feasible and successful actions. These aspects play a key role in those decision-making processes that determine the successful implementation of PLM within a group of companies.

The process of information gathering must be properly structured in order to provide different levels of detail in the analysis: at the initial inquiry stage, even simple questionnaires can be submitted to individual companies and partners at different organizational levels [13]. This will allow performing an initial assessment in order to understand where to concentrate, considering;

- Process layer
- Integration layer
- Application layer
- Data layer

Subsequently, targeted surveys may specifically investigate certain details among these areas.

Figure 1 Layered representation of the conceptual framework



3 Processes assessment [Process layer]

A first analysis should focus on investigating the awareness and knowledge of business processes in order to obtain a first assessment of the internal processes maturity, as to support their evolution and redesign. In general, the idea of maturity is presented by sketching a number of growth stages that depict the potential-upward development or performance of organizations during several sequential periods of time [13].

Another important aspect to be investigated is how the firm is able to set up a process-oriented framework to manage the PLM corporate strategy implementation (see [12]), that is the (re)definition of the business process model according to the new PLM paradigm.

Thus, the first step aims to verify the formalization of internal processes, verifying whether all management procedure are shared among the Company. In this assessment area, formalization is an important aspect to be considered because is directly connected to the aim of redesigning the processes.

In this perspective, the analysis may proceed incrementally, inquiring at first the methods adopted to classify the processes, assessing whether business processes are properly described, clearly stated and shared among the company. Then, it is advisable to identify the processes elements and the modeling methodology to describe:

- processes logics;
- information and material flows;
- resources, responsibilities and roles in each activity.

The adoption of some process modeling standards (e.g. BPMN - Business Process Modeling Notation [14], IDEF - Integration DEFinition [15], etc.) or process reference models (e.g. CBM – Component Business Model) can effectively facilitate the universal understanding of the processes representation, which is necessary in order to allow cooperation in managing the product throughout its life cycle.

The second step, with reference to the process layer, is related to the analysis on how to lead the progress of business processes towards a PLM “to-be” scenario. To this extent, it is necessary to understand how the typical processes in PLM [12] match the company core processes in the company:

- Integrated product design and process specification;
- Dynamic requirement management;
- Integrated management of ideas, project and product portfolio;
- Service and maintenance data reuse at product development;
- Lifecycle environment impact analysis;
- Total lifecycle costing;
- End-to-end configuration control.

In this step it is either advisable to verify how product life cycle management perspective is widespread and entrenched in the organization. Indeed, the following contents [12] should be easily recognizable into the company’s processes:

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- Idea management;
- Requirements management;
- Product structuring;
- Product program planning;
- Change management;
- Project controlling;
- Risk management;
- Quality controlling.

Last but not least, as far as the processes scope is concerned, supply chain relationships must be investigated as well. PLM logic clearly cannot be adopted without an effective information sharing between customers and suppliers. Thus, it is necessary to verify which processes – on both customer and suppliers sides – require the exchange of product information in each stage of the product lifecycle. This will help to identify the specific intervention of process redesign (input and output material and informative flows, operating and time constraints, roles and resources, performance evaluation and measurement criteria) according to the new PLM point of view.

4 Integration assessment [Integration layer]

Once the business processes are explored, the analysis moves on the technological field. Indeed, an effective and efficient processes management is based on prompt and correct information management and on feedback collection along the entire workflow. To this extent, the organization needs the proper technological infrastructure to grant information sharing at enterprise and supply chain level.

One of the typical weakness of the traditional processes management view – where product lifecycle stages are seen as distinct and separate elements – may originate from the presence of "islands of information" associated with those few isolated functions where the acquired know-how stagnates [5][4][6]. Aiming to a truly cross-function product life cycle view, an information sharing system – capable to spread product data both internally and externally, to suppliers, partners and customers, thus eliminating these "islands of information" – is surely necessary.

On top of an high-level architecture software networking, an EAI (Enterprise Application Integration) may support the linkage of product data management and organizational processes implementing information sharing through the various enterprise systems [7][1][8]. EAI acts as a high-level agent that set the roles for the different integrated systems in the enterprise and , inevitably, its implementation calls into question the structure of application and data layers, which are discussed further on. We report the main critical aspects that an EAI has called to cope:

- EAI must answer to the need of system dependency, and affects the application flexibility;
- EAI implementation projects requires important technical comprehension;

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- EAI must face different integration issues like information/data flows between business processes;
- EAI must be able to meet the daily requested performances and to assure exception handling and error-proof operations.

As seen for the process layer, the infrastructure assessment aims to understand the technological capability to support a PLM implementation project and to identify those aspects that need to be improved to fully switch to the PLM paradigm. On top of integrating the PLM system in some ERP system, it is important to focus on the elements which affect the decision to evolve/develop the technological infrastructure in order to enable a complete information sharing: among these, the specific requirements and operating constraints that characterize the interventions scope (such as the number of processes to connect, the amount and type of information to manage, the number of users to reach, the standards and security protocols to adopt, etc.) must be pointed out.

5 Applications assessment [Application layer]

This layer represents the technological connection point between the infrastructure and the product data collected from the processes. To this area belong all those heterogeneous – and often uncorrelated or independent – higher level applications dedicated to product information management and proper processes execution in the various functions, which need to keep a different point of view on the specific product. Their ability to interoperate ensuring a continuous data flow in alignment to the previously mentioned EAI aspects, plays a critical role in the PLM perspective [2][5][3][6] (e.g. despite the clear differences in the information systems, the CAD/CAE software used in the Design/Engineering division must however be promptly aligned with the application of the Maintenance, Logistics and Customer Service division to properly manage the preventive maintenance plans or spare parts replenishment).

Focusing on how to expand the awareness of integrating different applications – involving even suppliers and customers in the eventual choice of updating/purchasing new software – it is important to identify the operating requirements (in terms of capabilities, number of users, amount and type of data to manage, adopted standards, etc.) and constraints (related to capacity, security, budget, etc.). This predictable consideration should however be refined with the lessons learned from previous experiences of implementations of data interchange software in the company, on top of the analysis of the compliance of the selected applications with other systems (other applications or infrastructures), both inside the organization and outside it.

Information must be collected in order to point out how each of the company's functions can support the previously identified PLM typical processes: a gap analysis in order to identify the requirement and specifications to be met can thus be performed.

6 Product data assessment [Data layer]

The base layer in our framework is represented by product data. This is not intended as a mere file archive, but as a more complex data structure containing all information and metadata needed along the entire product lifecycle [1].

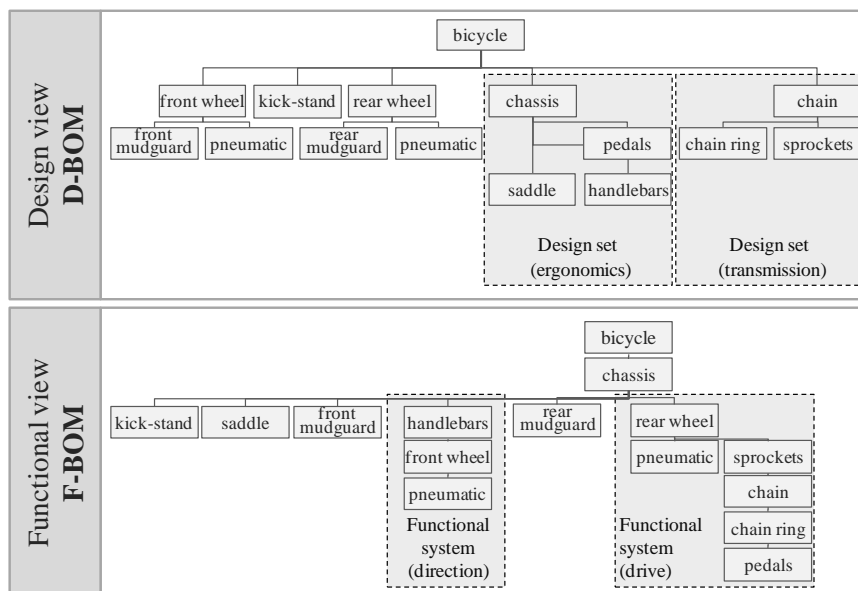
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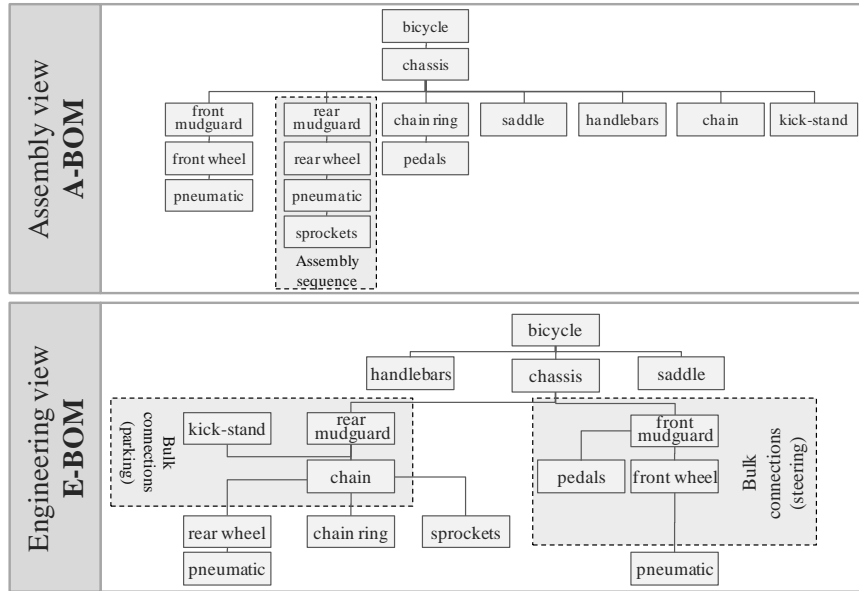
At first, the number and typology of products and parts managed in the company need to be analyzed in order to understand the complexity of the scenario. This may seem a simple task but, in the greatest part of the cases, Companies archive data in unstructured or inappropriate databases or, eventually, on paper. Thus, the complexity of this phase should not be underestimated. Data should be classified in accordance to the stage of the product life cycle [12].:

- design data;
- engineering data;
- maintenance data;
- configuration data;
- assembly data;
- production control data;
- data for activities scheduling on the product.

At first, it is important to point out *which* product data should be taken into account at each stage of its life cycle and, therefore, how the product configurations are managed and shared in order to properly arrange the required information. In this regard, suitable product break down criteria must be defined to identify the elementary units and what information should be collected. Product information can be structured in different ways: a functional point of view (F-BOM) will clearly differ from an assembly point of view (A-BOM), which in turn diverge from the structure used in the engineering division (E-BOM), etc. as show in figure 2.

Figure 2 an example of product data break down structures according to different points of view (X-BOM), related to a bicycle bills-of-materials.





The adoption of a unique protocol for PDM (product data management) allows to eliminate the conversion operations required to share information among different information systems. An ideal solution would be a default standard for product data management which can ensure full interoperability between software applications across the entire infrastructure. For this purpose, the knowledge on information structuring standards should be assessed both in the company and among the partners. In example, PLM requirements may be effectively supported by the STEP Application Protocol 239, namely the ISO 10303-239 standard, also known as the PLCS (Product Life Cycle Support) [9][6][10][11]. At last, it is important consider the characteristics of the application used to create, edit, review and share the product information.

Table 1 Analysis scheme for the data layer

	Internal context analysis	Toward the PLM approach
Process layer	<ul style="list-style-type: none"> • Processes identification and classification; • Standard modelling approach for processes representation and analysis; • Processes performance measurement; 	<ul style="list-style-type: none"> • Level of knowledge of PLM concepts; • Evaluation of processes in PLM areas; • Identification of linkages between internal and external (suppliers/customs) processes; • Identification of the necessary connections to implement the PLM logics.

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Integration/Application layer	<ul style="list-style-type: none">• Scenario analysis (requirements, operating constraints, etc.);• Adopted infrastructure/application and lessons learned from previous experiences (limits, constraints, etc.).• Analysis of the process coverage through infrastructure/applications;	<ul style="list-style-type: none">• Identification of PLM areas to be serviced through infrastructure/application;• Infrastructure capability to interact with external (suppliers/customers) systems.• Compliance with other internal and external (suppliers/customers) applications and infrastructure.
Data layer	<ul style="list-style-type: none">• Product data set complexity;• Managed product data informations;• Typology of product data (format).	<ul style="list-style-type: none">• Management and sharing of product data break down structure;• Standards for the interoperability with partners.

7 Conclusions

A conceptual framework that can support a large company, or a group of companies, in defining the assessment principles on which a PLM implementation project should be based on has been presented. The assessment model is required in the starting phase of the PLM project in order to understand the current scenario – inside a specific company or among several companies, at a corporate level – and the element that must be improved to support the transition from a traditional to a product-oriented approach. This may effectively help in identifying which specific interventions may be needed on top of creating a higher level of concern on the topic, together with the commitment that encourages the creation of a positive climate on which any kind of cooperative project should be based on.

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