Developing a PLM Framework: A Case Study Application in an Energy Company

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Abstract. Product lifecycle management has to be related to a business approach that requires IT solutions and also organizational changes in order to produce the desired effects. Different aspects (product data, people, processes, organization, IT technologies) needs to be integrated together for the achievement of a competitive advantage for the company. PLM needs of operational tools that can support the implementation of the theoretical principles. In particular, as extensively studied in the literature, company needs frameworks to refer for guiding the implementation of PLM initiatives and to support improvement actions. Based on an action research, the paper wants to describe the development and application of a PLM framework in Ansaldo Energia, an Italian leader energy company. The framework is product-centred and focused on processes and related IT systems. It allows to diffuse knowledge and culture on products lifecycle inside the company. Indications for the framework development in the ARIS Software AG are also provided.

Keywords: PLM, framework, lifecycle phases, processes, configuration management, IT systems.

1 Introduction

PLM means an integrated management of technological, methodological and strategic issues along the whole product lifecycle [1],[2]. A product data is not created and used only in a specific activity but it is linked to the whole set of data that are created and used during its lifecycle [3]. Having this awareness, inefficiencies related to waste of time, energy and resources can be avoided. Many companies refer to the PLM considering only the IT side and ignoring the organizational impact [4]. If it is underestimated, wrong investments and long time for IT deployment can arise. The understanding of these issues is not immediate. It needs a cultural change [5] based on a consciousness and knowledge of the impacts and relations among the whole product lifecycle elements.

Several scholars have developed models and frameworks on PLM (e.g. [6], [7], [8]) and have analyzed the industrial case studies (e.g. [9], [10]) to evaluate their validity. The available works don't explore the context of an energy company and don't propose a PLM framework and a corresponding methodology for process representation.

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Therefore, based on an action research between University and Industry, the paper explore a case study on PLM features and relations in Ansaldo Energia, an Italian leading energy company. A PLM framework is proposed and validated in the paper. The aim is to generate a pragmatic view around PLM for company working for complex product development in high-technological sectors, such as energy one. structure processes, activities, data and IT tools related to a specific product lifecycle are highlighted and represented in an organic and integrated structure. The proposed framework has been used by the company to diffuse a PLM culture and knowledge.

2 Background

A wide set of PLM model is available in scientific papers as a result of both theoretical and industrial research. The most comprehensive models in literature present a holistic PLM vision describing the complexity of PLM and harmonizing all its aspects in a limited set of key dimensions.

Budde et al. [7] include in their framework four elements important for the development and the implementation of PLM: strategy, process, product structure and IT-architecture. According to the author the challenge is not the selection of single solutions, but the integration of different tools and systems in the holistic implementation. Budde's model has been discussed by Silventoinen et al. [8], who add a fifth element, people and culture, in order to emphasize the importance of organizational culture and human factor in PLM implementation. Interrelation between key dimensions are defined both in Budde et al. [7] and Silventoinen et al. [8].

Others authors have proposed models that identify PLM main components. In Schuh et al. [6], the central point consists of a set of lifecycle oriented business process reference models which vary according to a group of company's characteristics. The centrality of business processes and product data are also the distinctive element of the PLM model defined by Abramovici [11]. He proposes a model that includes methods, models and IT tools for managing product information, engineering processes and applications along the different phases of the product lifecycle [11]. PLM is also analyzed by Rangan et al [5] that define just the broad scope of PLM specifying eight key dimensions: Business Drivers, Transformation Drivers, Domain Model, Generic Product Lifecycle, PLM tools, Implementation Drivers and Deployment Transition.

The role of processes in PLM is relevant as described in someone of the previous framework (e.g. [6]; [7]). Through processes, products evolve along the lifecycle and feedbacks (e.g. lesson learned and best practice) are diffused among the organizational practices. Different researchers have studied the relevance of processes in the product lifecycle. Messaadia et al [12] have explored the System Engineering processes to model PLM and concluded that this approach is complimentary to PLM to address the systems technology. Etienne et al [13] have proposed a interoperability platform based on product processes organizations. Schulte [14] instead has proposed a methodology to better integrate the customers' requirements of actual or attended products in the PLM functions, processes and metadata. As highlighted by Rangan et al [5], PLM processes need further exploration and a "cultural change management" is required in order to optimize organizational processes rather than individual benefits.

In literature, several case studies analyze the company practices in the PLM field. In the study of Golovatchev et al. [10], a telecommunication industry is explored and a PLM-process management approach is proposed and validated. This approach is suitable for complex products composed by several elements each-one characterized by a proper lifecycle. Some case studies have a technological focus such as the work of An Chiang & Trappey [15] in which a PLM system implementation in LCD industry is described through the proposal of a conceptual architecture of PLM. Focusing on companies working in complex sectors, there are specific case studies analyzing the aerospace and automotive sectors. For the aerospace sector, relevant studies are: 1) Alemanni et al. [9], which propose a KPI framework to test the adoption of a PLM tool, validated in an aerospace and defence company and 2) Lee et al. [16], which discuss two case studies from the aviation MRO companies in Singapore that stress the high potentiality of PLM applications. In the automotive sector, the study of Tang & Qian [17] needs a citation: it illustrates the PLM implementation among an OEM and its suppliers highlighting practices and characteristics.

Therefore, several researchers have argued both on the PLM representation in framework and models and on the relevance of PLM as a business approach integrating different companies' perspectives. In a high quantity of studies, the role of processes is clearly highlighted and included in the PLM treatments as a central element. Furthermore, to support the wide relevance of PLM for the companies practices several case studies are available that discuss and make relevant the strategic role of PLM both as a technology and as a business approach in different industrial sectors. None of the analyzed cases study in literature are focused on the energy sectors but best practices and lesson learned can be grasped and extended. This element is relevant to highlight the uniqueness of case study research focused on a specific object.

Additionally, in literature it doesn't exist an holistic PLM framework described with a methodology for process representation that support and allow a further extension and replication.

Finally, several are the enterprise architecture frameworks (i.e. Zachman Framework [18], CBM [19], DCOR [20], APQC [21], CMMI [22]) that treat the representation and integration of different organizational dimensions in a unique framework. This enterprise architecture framework however miss of a focus on the product and on its lifecycle. For example, configuration management aspects are not treated as a whole. Suggestions of linkages among elements and the use of standardized item name (e.g. such as for APQC) have been considered and integrated in the research results.

3 Research Design

3.1 Research Method

Based on the previous literature background, the paper wants to describe the development and application of a PLM framework, product-centred and focused on processes and involved IT systems, in an energy company. The main research question that the paper wants to address is: How to represent a PLM framework for complex products in order to diffuse a PLM culture and share features and insights of a product lifecycle?

This question has emerged as aim of an action research in which University of Salento was involved with its partner company Ansaldo Energia in the MindSh@re community of Finmeccanica. The paper presents an industrial case study based on the results of the carried out action research.

A case study is particularly appropriate to study contemporary events and non-controllable units of analysis [23]. The case study is thus guided by the pragmatism knowledge claim: it is problem-centric and the attention is therefore placed on the problem and how to solve it in a real organizational setting [24]. Multiple sources of evidences have been used to increase the case study's construct validity [23]: the direct researchers' observations and interviews with key users. Most of the information was collected through a set of interviews to key company referents. They are a convenience sample since are involved in the phases of product lifecycle as manager or responsible [25]. For each phase, a key informant have been involved and information have been shared and collected with its collaboration. An open-ended questionnaire has been administered at each key informant to better stimulate perspectives, views and opinions sharing among the participants [24]. The key informants have reviewed the case study report and validated the main findings and conclusions. Data and information of the PLM framework have been represented using the software ARIS Business Architect 7.1. This software is suitable to create, analyze, manage and administer an enterprise process architecture.

3.2 Research Context

Ansaldo Energia (AEN) is a Finmeccanica Group company and is the Italian largest supplier, installer and service provider for power generation plants and components. AEN is a manufacturing company working in the production of gas turbines, steam turbines and generators (hydro and air-cooled generators) dedicated to energy production. Depending on the contract type, AEN provides a variety of system configurations ranging from the simple supply of machines to the design, implementation and management of the entire plant.

AEN considers the PLM as essential and strategic to manage information, processes and resources that support the product along its lifecycle, from the conceptualization to the design, from the manufacturing to the sell, until the maintenance.

4 Results

4.1 The PLM Framework

Each time a company's product is designed, physically realized, delivered to a customer and, in some cases, also maintained and disposed, its lifecycle is put into effect requiring several resources and impacting on different organizational dimensions.

The structure of the proposed PLM Framework is composed by four blocks and related relational levels. The four blocks are: Block A - PLM Definition and Foundation; Block B - PLM Phases and Processes; Block C - PLM Configuration Management Views; Block D - PLM IT Architecture.

The PLM Framework can be developed for each product typology in the company. Each product has its own phases of lifecycle led by the processes execution. During the activities done in the processes, the product data evolve and are represented in the configuration management (CM) views. IT tools are used in the processes and make available the CM Data.

Each block is designed to be detailed for including further relevant information. A specification of detail levels with the corresponding ARIS models is available:

- Block A: 1) Company's products (as Product-Tree), 2) Structure of Products (as Product-Tree) and 3) Structure of Products Component(as Product-Tree).
- Block B: 1) Synthesis of company's products lifecycle (as Value-added Chain Diagram), 2) Product Lifecycle Phases (as Value-added Chain Diagram), 3) Processes for a specific Product Lifecycle Phase (as Value-added Chain Diagram), 4) Process Activities for a specific Product Lifecycle Phase (as EPC column display) and 5) Detail of IT systems, inputs, outputs and organizational units for an activity (as Functional Allocation Diagram)
- Block C: 1) Sets of Configuration Management Views for company's products (as Value-added Chain Diagram), 2) Product Configuration Management Views (as Value-added Chain Diagram) and 3) Metadata, software and activities for the Configuration Management View of a given Product (as UML Class Diagram).
- Block D: 1) Sets of IT systems for company's products (as EPC), 2) Product IT Systems (as Entry Diagram) and 3) Details (available modules, integrations and supported activities) of the IT system for a given Product (as Entry Diagram).

About the first two levels of the lask block, IT systems are specified as isolated entities that are used for different aims and in different moments of the life-cycle. In the third level "Details", instead, the integration among the different IT systems are specified, if it is present. Generally, in the practice of the companies is almost impossible to observe that all the software tools used along the lifecycle of a product are directly integrated without the need of re-working or uploading among different systems. This evidence justify the chosen block structure.

4.2 The Application in AEN

The gas turbine has been chosen as test-case for the application of the PLM Framework. It is a core product for AEN and is considered as a "single equipment" that can be expanded including also the whole plant or the maintenance services.

According to analyzed AEN practices, the following lifecycle phases have been defined:

- Plan: a product life cycle starts with the definition of the company strategic plan that include research and business initiatives.
- Concept Development: incremental or radical innovation activities on existing products are carry out to satisfy the needs of a specific customer or to increase and improve the company products portfolio.
- Product Design: when a job order is received, product changes and installation details are designed.
- Manufacturing: it is comprehensive of all the industrialization activities, including two fundamental moments the productive process design and the effective production.
- Sell & Distribution: the realized product is delivered and installed at the customer site.
- Service: when the product is operative in its site, a set of maintenance activities are executed based on the agreement conditions.
- Disposal: an AEN product lifecycle is very long but if established by agreement, at the end of its lifecycle, it can be retired and its recyclable and un-recyclable components adequately managed.

The Lifecycle Phases are characterized by Technical Processes [26] based on technical activities executed in the lifecycle for realizing the customers desired products. The Lifecycle Phases with their Technical Processes are supported by Project Processes [26] that allow to manage resources and assets allocated to a project. Among them, in the specific case of AEN, the Tollgate Process and the Product Configuration Management Process are highlighted.

For each lifecycle phase, the Technical processes have been identified (e.g. Figure 1) and for each process, the activities, IT systems and data have been modeled using the EPC (Event Process Chain) standard. A Function Allocation Diagram (FAD) have been created for the activities with more than one input, output or IT system. Such activities have been extracted from the process and the related features have been assigned.

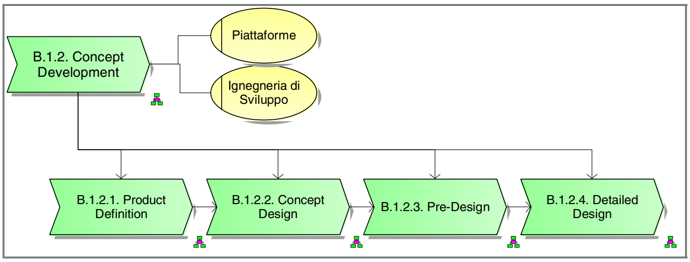

Fig. 1. Processes of Gas Turbine Concept Development phase

The configuration management views recognized and managed in AEN are As Designed, As Planned and As Delivered. A CM View is a visualization of data in a specific moment of the lifecycle allocated for specific tasks. Such data are available on information systems and represents the product features. Therefore, for the aim of the Framework, the CM views have been broken up in their meta-data (e.g. Figure 2). IT systems in which are available, and activities in which are created, have been also specified.

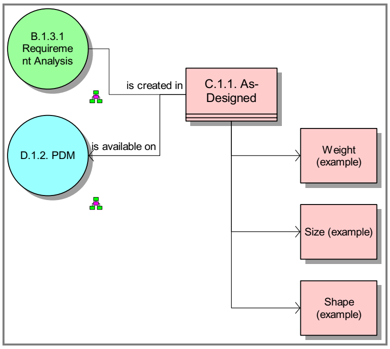

Fig. 2. Detail of As-Designed View (for privacy issues, meta-data are reported as example)

In AEN, several IT systems are used to manage and execute processes and to store configuration management data. A type classification is: Product Lifecycle Management (PLM) System, Product Data Management (PDM) System, Computer Aided Design (CAD) System, Computer Aided Engineering (CAE) System, Computer Aided Manufacturing (CAM) System, Project Management System, Enterprise Resources Planning (ERP) System, Legacy Software, Optimization Software and the Materials Database (DB). AEN has both a PLM and PDM System, this last one is mainly used as Document Management System in some processes. For each IT system, a map has been realized with available modules, supported activities and integration with others tools.

The analysis done for product data, processes, configuration management views and IT systems along the gas turbine lifecycle, is summarized in the following figure that represents the high level of the PLM framework for AEN.

The Framework is easy to navigate by simply clicking on the selected item both in the ARIS software and in a web format (html) that can be integrated in companies' portals. The use of the software ARIS Business Architect 7.1 have allowed to satisfied the need of a better traceability, integration and representation of the Framework elements thanks to the availability of several models suitable for each block's element. Furthermore, the Framework elements are structured in folders guaranteeing an easier consultation and exploration.

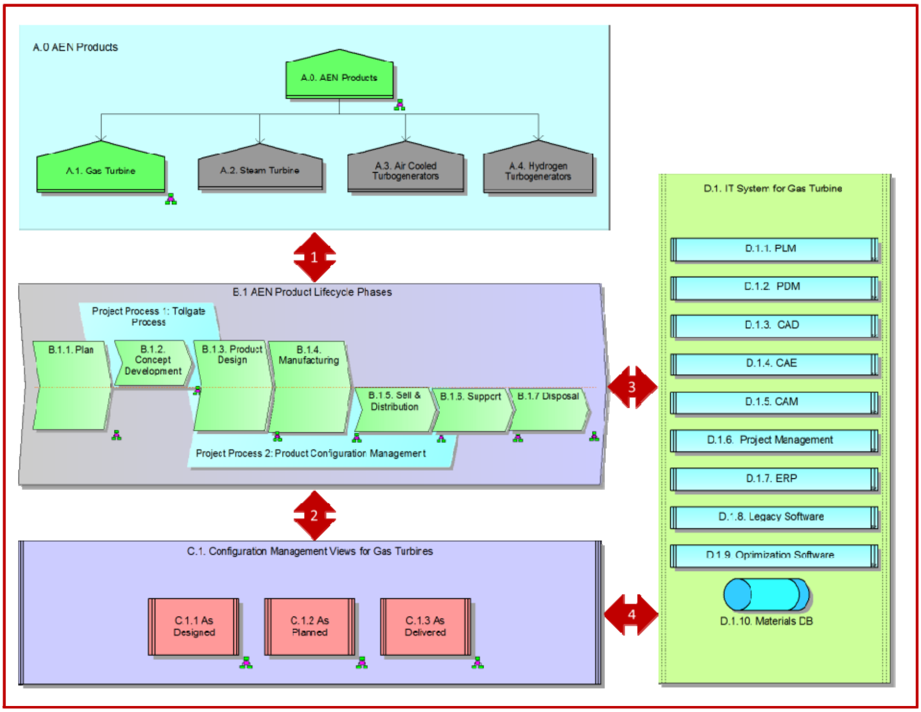

Fig. 3. PLM Framework for Gas Turbine in AEN

5 Discussion and Conclusion

In the study, the context of the company Ansaldo Energia has been explored and structured around a PLM framework suitable to represent in an integrated scenario product data, processes, configuration views and IT systems. The study results provide an evidence from a real company practices in the PLM field and suggest the adoption of a PLM framework detailed using the software ARIS Business Architect. In the paper, indications on the selected ARIS models for the representation of the Framework are also provided that can be used to replicate the framework in others contexts.

In the PLM Framework, the lifecycle is represented as an integrated framework in which data, processes and IT systems co-exist and are linked. The main field of application of the PLM Framework is to create a reference for the PLM issues inside the company. It can be used for documentation purposes inside the company in order to diffuse a PLM culture and knowledge among the employees. In this manner, the employees are stimulated to think to their job as a small part of a wider set of activities that impact on the whole product lifecycle performance.

The PLM Framework can also be useful in performance measurement of processes and IT inside a company or among different companies, as it provides a reference to assess performances on a wider scope, covering the whole product lifecycle, instead of providing measurements of individual elements separated from the whole context. Furthermore, representing IT and processes for different products, it allows to compare the different company scenarios and can support the design of improvements and rationalise initiatives.

Such a tool, as correlates all the different parts, allows a more accurate assessment of the effort and of the impacts that a change in the company (e.g. a change to a process, an update of an IT system, etc.) can have in terms of cost and/or performance over the entire lifecycle. It can be used to better manage the change management process.

Future research will be dedicated to better formalize the PLM framework methodology and apply it to other organizational contexts within Ansaldo Energia and in other companies as well.

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