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Enterprise Modelling: Building a Product Lifecycle (PLM) Model as a component of the integrated vision of the enterprise

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Abstract: Enterprise modelling has proved to be an efficient tool to study organisations' structure and facilitate decision making. The enterprise is a complex system that is required to use its processes to generate value in a given environment (concurrent, market, suppliers and humanity). We focus on three management disciplines: Product Lifecycle Management (PLM), Supply Chain Management (SCM) and Customer Relationship Management (CRM). These business processes are so intertwined that the enterprise has to concentrate on the three to attain its economic objectives. To enhance the development of PLM, SCM and CRM models, the enterprise needs to capitalise the knowledge necessary to adapt and apply modelling techniques. Knowledge Management (KM) is a key factor to give a unified enterprise vision. Firstly, we propose an integrated enterprise model depicting the interactions between PLM, SCM, CRM and KM models. But a state of the art showed that PLM models are scarce. Most of the PLM models found depends strongly on the particular case studied and can not be used with other enterprises. After defining the most important components of the PLM vision, we propose to organise these components into a formalised way. The study of SCM and CRM models proved to be helpful to structure these components. Finally the validation methodology that is to be established in our coming research works is not only to be used with the PLM model presented in this paper but with SCM and CRM models also.

Key words: Enterprise Modelling, Enterprise Systems, Product Lifecycle Management (PLM),

1- Introduction:

Enterprises, today, are facing a rapidly changing environment; they can no longer make predictable long term provisions. To adapt to this change enterprises need to evolve and be reactive so that change and adaptation should be a natural dynamic state

rather than something occasionally forced onto the enterprise. This reactivity necessitates the identification of the core enterprise processes and the development of a discipline that organises all knowledge that is needed to identify the need for change in enterprises and to carry out that change expediently and professionally. In this paper we are interested in three core business processes, Product Lifecycle Management (PLM), Supply Chain Management (SCM) and Customer Relationship Management (CRM). Those three activities are so intertwined that the company has ideally to work on managing its supply chain, its product lifecycle organisation and its customers' relations in order to attain its economic objectives, evolve in the global market and assure its permanence in the socio- technical environment. Besides Knowledge Management (KM) could be a determinant factor to integrate enterprise key process and enhance their use.

We focus on three management disciplines, the Supply Chain, the Customer Relationship and the Product Lifecycle. Besides we try to show the role of Knowledge management. If the supply chain, the product lifecycle and the customer are proved to be key success factors in the enterprise, recent studies (1990) are the role of Knowledge Management is enterprise systems.

In the first part of this article, we give an overview of enterprise modelling practices. Then we present, in the second part, our vision of enterprise systems and the interaction between four key management functions: Product Lifecycle Management (PLM), Customer relationship Management (CRM) and Supply Chain Management (SCM) as well as the position of Knowledge Management.

The third part of the article is focusing on PLM models. In the literature, there is scarce PLM modelling attempts, so we are proposing a model to illustrate the PLM vision with a semi- formal language (combining pictograms and formal

language). The steps that led to building this model are explained too.

And finally, we expose the future research work that is based on model validation.

2- State of the art in Enterprise Modelling:

During the last decades, enterprise modelling has proven to be a fertile research field. Numerous modelling approaches were settled down and proved their effectiveness when modelling the enterprise processes, information system, resources or organisation: SADT, SASS, The IDEF family of languages (IDEF0, IDEFx1, IDEF3..), CIMOSA, GRAI TOOLS, PERA, GERAM, ARIS...These previous enterprise modelling methodologies aims to provide a better understanding and a uniform representation of the enterprise, support for designing new parts of the enterprise and a control and monitoring enterprise operations [Vernadat,1996].

The most important research results and some of the reference papers investigating could be seen in Table1. We are trying, also, to have them organised into: functional based approaches, data/information based approaches and resource based approaches. Vernadat adopted a similar classification in his books [Vernadat 1996, Vernadat 1999].

Approach	Modeling Method	Main references
Function	IDEF0 (Integrated Computer-Aided Manufacturing Definition)	The IDEF family of languages. Christopher Menzel & Richard J Mayer. University of Texas, www.idef.com
Function	SADT Structured Analysis and Design Technique	D.T. Ross, "Structured Analysis (SA): A Language for Communicating Ideas," <i>IEEE Transactions on Software Engineering</i> , vol. 3, no. 1, pp. 16-34, Jan/Feb, 1977
Function	IDEF3	The IDEF family of languages. Christopher Menzel & Richard J Mayer. University of Texas, www.idef.com
Function Data/Information	IDEF _x 1	The IDEF family of languages. Christopher Menzel & Richard J Mayer. University of Texas, www.idef.com
Function	SASS (<i>Structured Analysis and System Specification</i>)	T De Marco. Structured analysis and system specification. ACM Classic Books Series Classics in software engineering 1979
Function Data/Information Resources	CIMOSA CIM Open System Architecture	- ESPRIT-AMICE. CIM-OSA - A Vendor Independent CIM Architecture. Proceedings of CINCOM 90, pages 177-196. National Institute for Standards and Technology, 1990. -CIMOSA: enterprise engineering and integration, K. Kosanke a, F. Vernadat, M. Zelm, Computers in Industry 40 1999.83–97
Function Data/Information Resources	GRAI	G. Doumeingts, B. Vallespir, D. Chen, GRAI grid, decisional modelling, in: P. Bernus, K. Mertins, G. Schmith (Eds.), Handbook on Architecture of Information System International Handbook on Information Systems, Springer, Berlin, 1998.
Function (Process) Data/Information Resources	GERAM	GERAM: Generalised Enterprise Reference Architecture and Methodology. IIT Force 1999

Table 1: Main Enterprise Modelling techniques

The development of enterprise modelling solutions, though, was mainly based on the identification of core business processes and the way they are used in day-to-day operations to assume the enterprise functions. We will represent next the four enterprise core businesses we are focusing on in this research: Product Relationship Management (PLM), Supply Chain Management (SCM), Customer Relationship Management (CRM) and Knowledge Management (KM). The interactions studied between the models used to insure SCM, CRM, PLM or KM can help the enterprise's management choose the suitable strategy and enhance the application of the chosen model in practice.

Combining the study of PLM, SCM and CRM allows a covering of all enterprise's aspects: the Functional part, the Data/information part and the Resources part. PLM is an Information/Data/Functional approach. It is based on functional interoperability between the enterprise departments and keeping traceability in product data during the lifecycle [Terzi, 2005]. SCM is mainly a Functional approach, it is based on detailing (creating, sourcing, making processes and logistics functions) supply chain functions to facilitate their coordination and improve the performance of the entire supply chain [Li et al, 2005].

CRM and KM are to be considered as Information/Data/Resources approach. CRM needs collecting customer' data which are implemented on different Information systems. KM aims at a better use of enterprise resources via Knowledge and allows the capturing, externalisation, formalisation and structuring of knowledge about enterprise processes [Kalpic & Bernus, 2002]

3- An integrated Enterprise Model:

In this research we consider an enterprise "made of a large collection of concurrent business processes executed by a set of functional entities (or resources) that contribute to business objectives" [Vernadat, 1996]. Managers need efficient tools for process modelling and integration [Vernadat,] to give them guidelines to conduct organization improvements [Melan, 1993]. We are proposing to study the most important of these enterprise process models in order to enhance their application, so following the classification of Shrivastava et al (1999), we are interested in three core business processes: Supply Chain Management (SCM), Product Lifecycle Management (PLM) and Customer Relationship Management (CRM).

The paper of Shrivastava et al (1999) is focusing on Supply Chain Management (SCM), Product Data Management (the Product Data Management discipline has evolved to PLM since that) and Customer Relationship Management (CRM); it depicts the interactions between these business processes. This interaction is meant as follow: improving the enterprise efficiency with managing its Supply Chain, its Customers or its Product is almost related to working on the other enterprise factors.

This vision is confirmed by Hervé Rolland, Vice president of sales development of IBM who considers that the PLM and CRM are the enterprise front office and the SCM and ERP are the enterprise back office. [Debeacker, 2002].

We will begin by a brief definition of those three enterprise management disciplines, and then we will explain the interactions between them.

3.1 – Definition of Product Lifecycle Management (PLM):

The past three decades have seen phenomenal growth in investments in the area of product lifecycle management (PLM) as companies exploit opportunities in streamlining product lifecycle processes, and fully harnessing their data assets. These processes span all product lifecycle phases from requirements definition, systems design/ analysis, and simulation, detailed design, manufacturing planning, production planning, quality management, customer support, in-service management, and end-of-life recycling. [PTC, Needham, MA].

PLM systems will support business partners across the supply chain with needed product information and more process integration (Supply Chain Management). Furthermore PLM systems will support feedback of customer information into earlier product lifecycle phases to improve product quality (Customer Relationship Management). [Abramovici et al, 2002]

3.2 – Definition of Supply Chain Management (SCM):

The Supply Chain is the set of procedures and software using for managing optimally the information flows, material flows and the interfaces between the different actors: suppliers, producers and customers that are related to the manufacturing of a product or the delivery of a service. All the data concerning from the customer requirement until the distribution scheme, through the conception and production data are gathered and used to build the supply chain [Eymery, 2003].

Supply Chain Management, though, consists of monitoring, supervising and integrating all key business activities from the final customer down to the raw materials suppliers [Global Supply Chain Forum (GCCF): ou connue avent pour le "Research Roundtable of the International Center for Competitive Excellence, de l'Université de la Floride du nord]: customer relationship management, customer services management, demand management, order fulfilment, manufacturing flow management, procurement, product development and commercialization and returns [Lambert et al, 2000].

3.3 – Definition of Customer Relationship Management (CRM):

Acquiring, retaining, and partnering with selective customers to create superior value for the company and the customer is the main objective of Customer Relationship Management [Parvatiyar& Sheth, 2001]. Customer Relationship, in fact, is the "process that involves the development and leveraging of market intelligence for the purpose of building and maintaining a profit-maximizing portfolio of customer relationships" [Zablah, et al 2004]. CRM allows companies to gather customer data swiftly, identify the most valuable customers over time, and increase customer loyalty by providing customized products and services [Rigby et al., 2002].

3.4 – The Enterprise Integrated Model:

SCM, PLM and CRM models are important success factors for an enterprise. Those three activities are so intertwined that the company has ideally to work on managing its supply chain, its product lifecycle organisation and its customers' relations in order to attain its economic objectives, evolve in the global market and assure its permanence in the socio-technical environment. But, we are adding a fourth factor that we consider part of the important resources of an enterprise or an organisation: Knowledge.

In fact, knowledge is an economic capital and a strategic resource in the enterprise, it provides a competitive advantage and insures a stability for the company as it deals with the strategies, the organisational structure, the whole set of processes, the human resources, communication and information technologies. [Boughzala & Ermine, 2002].

The term "Knowledge Management" is more than twenty years old. Karl Wiig, management consultant, coined it at a 1986 Swiss conference sponsored by the United Nations [Liebowitz, 1999]. One of the definitions of KM is that it "involves the identification and analysis of available and required knowledge, and the subsequent planning and control of actions to develop knowledge assets so as to fulfil organisational objectives". [Ann Macintosh, Artificial Intelligence Applications Institute, University of Edinburgh].

Besides the three success factors: the supply chain, the product and the customer, the question of knowledge handling emerged in the literature as a discipline that can help the enterprise achieve their economic goals and preserve their "know how" inside the company despite the renewal of workers.

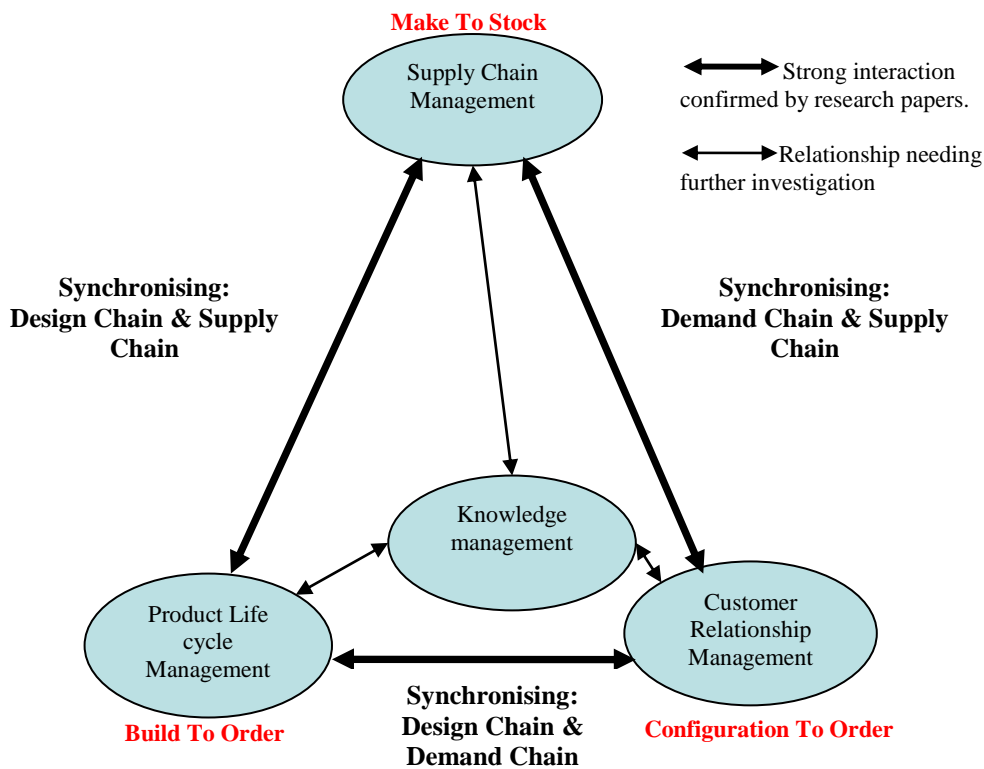


Figure 1 : An integrated Enterprise Model: Interactions between PLM, SCM, CRM and KM models

In Figure1, we are trying, also to picture the strong interaction between SCM-CRM, SCM-PLM and PLM-CRM using double bold arrows. This idea is consolidated by the work of Denis Debeacker [Debeacker, 2005] who specifies these links. In fact PLM and SCM systems are keen on developing the Supply Chain and the Design Chain. PLM and CRM systems are interested in coordinating the Design Chain and the Demand Chain. Finally SCM and CRM systems are working on a better synchronisation of the Demand Chain and the Supply Chain. Below we further discuss the meaning of these links.

3.4.1 – Interactions between Enterprise models:

Some of these six interactions are, already, well described in the literature (CRM-PLM, CRM-CM, PLM-SCM). But some others have to be more detailed and that is what we propose to do in the following step of our research.

First, the product lifecycle affect both the supply chain and the customers. The parts list determines the number of suppliers in the supply chain and their rows. The total lifecycle governs delivery deadlines to the customer. Chiang and Trappey [Chiang and Trappey, 2007] and Sudarsan et al [Sudarsan et al, 2005], for example, pointed out the role of PLM in enhancing SC and CR management.

Second, Customer knowledge is used in PLM and SCM models and decisions carried out in those two processes affect the customer on form of product final form or deliveries times [Mehtala et al, 2007]. Debeacker [Debeacker, 2005] demonstrates the important challenges of PLM which is to synchronise the Design Chain (supported by PLM practices), the Supply Chain (supported by SCM practices) and the Demand Chain (supported by the CRM practices).

Besides, Customer relationships affect both the product lifecycle and the company supply chain. [Parvatiyar and Sheth, 2001]. Parvatiyar and Sheth continue by explaining that CRM involves the integration of marketing, sales, customer service, and the supply-chain functions of the organization to achieve greater efficiencies and effectiveness in delivering value..

Each company seeks to attend a high customer satisfaction level by adapting its product to the customer demands. Supply Chains are organised or re-engineered according to the customer requests. Supply Chain Management models require customer's requirements as well as the specific company's processes and data to represent the global Supply Chain. SCM research concludes that close customer relationship allows an organisation to differentiate its product from competitors, sustain customer loyalty and dramatically extend the value it provides to its customers [Magretta, 1998].

3.4.2 – Knowledge as an integrating element:

Inside the triangle, the double arrows depict the interaction between KM and each one of the business process introduced earlier.

Knowledge is recognised as being “the key capital of enterprises” [Kalpic and Bernus, 2002] that contributes to enterprise competitiveness and provides the basis for long term growth, development and existence. KM could be seen as a discipline integrating the other enterprise models: PLM, SCM and CRM given that enterprise models are a formalisation of enterprise knowledge [Kalpic and Bernus, 2002]

Research papers have addressed the KM-CRM interaction widely, are getting interested in the KM-PLM interaction, but few papers pointed out explicitly the role KM-SCM interaction. That is why we represent, KM closer to CRM first and PLM second.

In fact, the CRM domain is strongly related to KM, new researches talk about “Customer Knowledge management”. In particular, customer knowledge and customer knowledge management (CKM) have recently become a major focus of interest for companies who want to enhance their customer relationship management (CRM) capabilities, obtaining and utilizing Customer-related knowledge is a prerequisite for attaining CRM objectives [Mehtala et al, 2007].

Knowledge capitalisation is an important issue on PLM, too, as it is important for the company to know which knowledge to use for a PLM system, how to collect this knowledge and how to update it when the company or the product evolves.

3.4.3 – Business models to complete the entegrated enterprise model:

To complete our integrated enterprise model, the business models that are applied in each case are signalled. Business models underline “the economic logic that explains how we can deliver value to the customer at an appropriate cost” [Joan, 2002]. There are three know industrial profiles: Make-To-Stock, Build-To-Order and Configuration-To-Order [Chiang et Trappey, 2007].

Make-To-Stock is applied in mass production industry with standardized products [Arnold & Chapman, 2004] such as process industry and some agro alimentary industry when perish ability limits allow to make stocks. Make-To-Stock industries are characterised by a sales forecast production plans, little direct participation of the customer in the production and the shortest delivery lead time [Dilworth, J.B., 2000]. Under a Make-To-Stock production, companies opt for using Supply Chain Management models, they allow a better stock management give a great importance to delivery dead lines and allow continuous process flow [Donlon, J.P, 1996].

Build-To-Stock is commonly used for one-of-the-kind, customised products [Arnold & Chapman, 2004]. Aerospace Automotive ad Electromechanical industries are mainly following a Build-To-Stock production [Terzi, 2005].

Build-To-Stock industries are using collaborative product designs (established with the customer), high customer enrolment all along from design to delivery and relatively long delivery lead times comparing to Make-To-Stock [Arnold & Chapman, 2004].

PLM models are often used in a Build-To-Stock production system. Chang and Trappey's study [Chiang et Trappey, 2007] concluded that PLM components like “Requirements management (RM), Bill of materials management (BMM) or Supplier relationship management (SRM)” are highly used under a Build-To-Stack business model.

Configuration-To-Order is between Make-To-Stock and Build-To-Order. This way of product design is more suitable for a mass production organised into two parts: a manufacturing first part and a customised assembly second part [Chiang et Trappey, 2007]. Customer involvement is relatively limited compared to the Build-To-Stock production but delivery lead times are reduced further [Arnold &

Chapman, 2004]. Configuration-To-Order is offering customised products and personalized services. Relationship with customer is, though, crucial for corporate enterprise survival [Wines L. 1996]. CRM are often used in this configuration [Suhong Li et al, 2005].

Apart of these three business models, we have not found papers showing a business model that fits the simultaneous application of SCM and PLM, SCM and CRM or CRM and PLM.

4- Building a PLM Model:

4.1 – Luck of PLM Models:

Enterprise modelling techniques are proposing a set of models to enhance companies' performance in each one of these domains. But managers need to understand these emerging models as quickly as possible, compare their theoretical and practical validation and adapt them to their companies' specifications. We aim at providing the managers with a modelling technique allowing them to understand the previous enterprise models characteristics and decide to apply the models aligned with their strategic objectives.

SCM is proposing different models to depict a supply chain. A simple flow diagram is meant to depict the important components of a supply chain and the flows exchanged between them. Part of the "lean manufacturing tools", the Value Stream Mapping model is supposed to give a broader view of the supply chain of a company and offers alternative tools to make physical and information flows run easier and to reduce wastes in the supply chain.

CRM models are based on diagrams defining the context of the study and the possible actors in interaction then hypothesis are made concerning the possible relations or interactions between those actors when managing the customer relationship. Finally interviews and case studies confirm or reformulate the initial hypothesis to obtain a model linking different actors in a customer relationship context.

As a recent issue in the literature, we could find few models of PLM most of which depends strongly on the particular case studied and can not be used with other companies. We try to build a general PLM model supporting PLM principles and allowing managers to apply a PLM strategic vision of their company.

4.2 –Steps to build a PLM model:

The PLM model proposed in this article is meant to enhance the comprehension of the PLM vision. It is based on the previous research results and a literature review among the papers dealing with PLM. Our model is based on a semi-formal language, pictograms and symbols are organised to according to the most important PLM principles.

The PLM model must keep track of the Lifecycle phases of the product depicted. As pointed out by Stark [Stark, 2005], PLM is "the activity of managing a product across its lifecycle, from cradle to grave, from the very first idea for the product all the way through until it is retired and disposed of".

It is important for the company to have full details about the lifecycle. PLM existing models give a view of the lifecycle phases but the degree of details differs.

In fact three important phases compose a product Lifecycle: the Beginning Of Life (BOL), the Middle Of Life (MOL) and the End Of Life (EOL) [June et al, 2007], [Abramovici et al, 2007] [Kritsis et al, 2003]. But for a better understanding of the product, the enterprise must have more details about its lifecycle. Further PLM studies give a larger importance to the life cycle phases. June et al introduced design and production phases in the BOL of a product, maintenance, use and distribution in the MOL and finally remanufacturing and disposal in the EOL. After introducing different lifecycle models (such as GERAM Lifecycle model, STEP Lifecycle model,...), Terzi opted for a detailed lifecycle model too based on four major steps: product development, product production, product use and product dismiss. Each one of these phases is then decomposed into different steps.

Chiang and Trappey, proposed a full detailed lifecycle view including requirement planning, conceptual design, manufacturing planning, manufacturing & test, maintenance and disposal & recycling.

In our PLM model we propose to give further details about each lifecycle phase ranged into BOL, MOL and EOL phases. Each phase is held into a box that shows, at a first level, the number of staff working on it and, at the second level, the main results obtained.

BOL includes concept development, Product design, Prototyping& testing, process planning, supply chain planning and production. The transition between these first phases of the lifecycle consists of information flows mainly (black arrows in the diagram) such as: product design specifications, prototype test results, design changes, Bill Of materials Details...

MOL includes delivery& installation and maintenance& other services to the customer. Material and product flows (Blue bold arrows) are added to the flows exchanged between different stages.

Finally EOL includes removal& disposal and recycling. The information & material flows are exchanged between these phases. Besides, recycled materials and product parts for reuse are, ideally, turned back to the first stage of the product lifecycle. Interoperability and traceability are the main issues to consider when building a PLM model [Terzi, 2005], [Terzi et al., 2006]. To keep track of the product and its evolution through the lifecycle phases we opted for settling down a unique data base. It holds the information and the knowledge from all lifecycle phases.

Including a knowledge base in the PLM model, helps knowledge management activities: knowledge capitalisation, knowledge sharing and knowledge creation. These activities are said as part of the PLM vision [Stark, 2005].

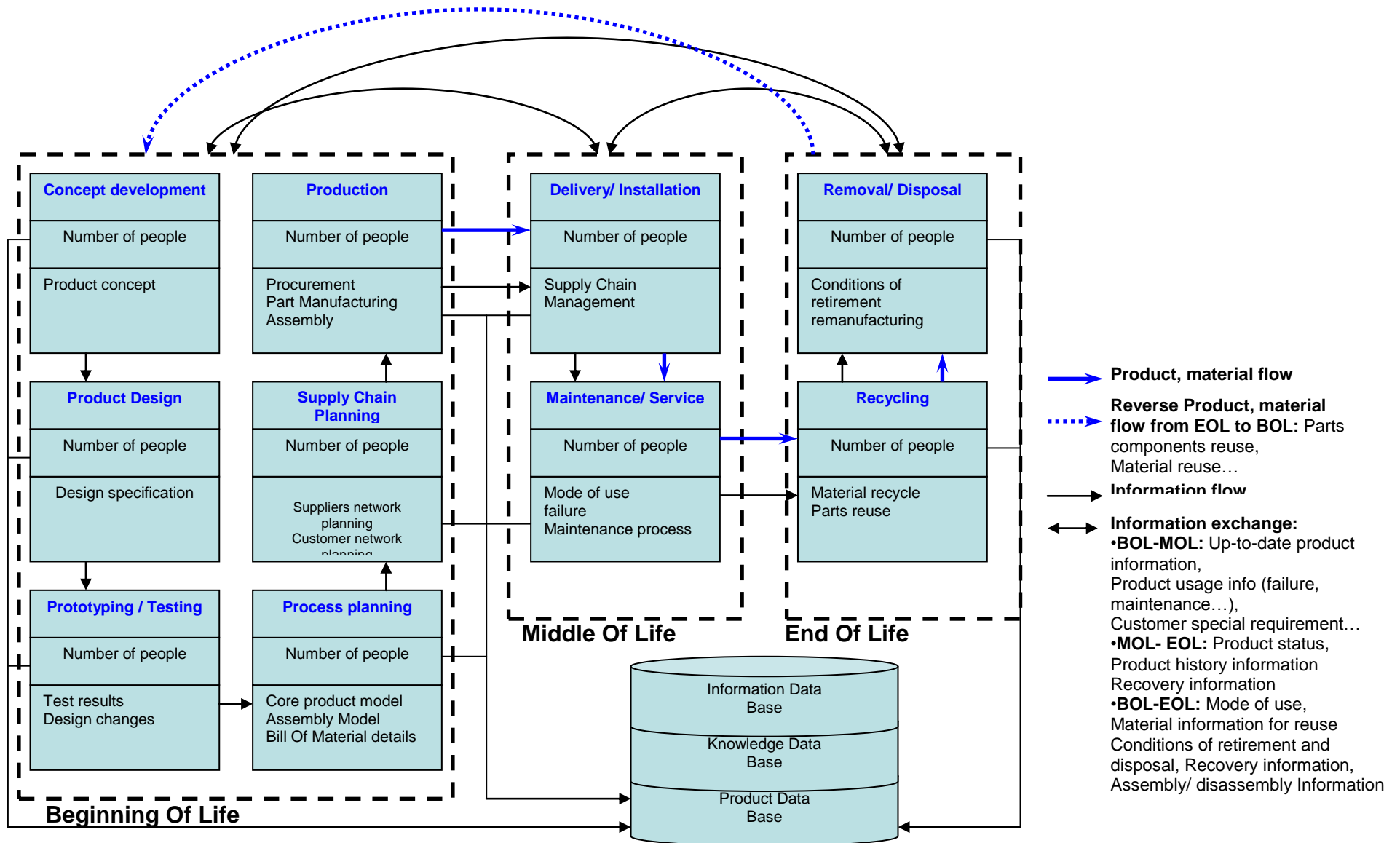


Figure 2 : A proposition of a PLM model

5- Discussion and research perspectives:

Building a PLM model is essential to complete our integrated enterprise vision. But we have not addressed yet the validation of the proposed model. This issue will be part of our future researches as the study of enterprise models includes a focus on the validation technique.

As part of our integrated enterprise vision, we began by studying the validation techniques used with SCM and CRM models.

Many SCM models are validated by case studies [Abdulmalek & Jayant. 2007.] proposed a Value Stream Mapping model through the Supply Chain of steel manufacturing company. The results of their model were validated by the improvements obtained when using the model in the company.

Avlonitis and Panagopoulos [Avlonitis et al, 2005] proposed a CRM model for implementation of CRM technology and its impact on sales performance. All hypotheses were tested on a case study including pharmaceutical firms and using interviews.

The validation methodology proposed will not, only, be used on the PLM model proposed in this article. The objective of our research is to try to prove the validation of SCM models, CRM models and KM models. Managers are facing too many enterprise models and must choose between them the most effective one. Providing them with a theoretical and practical validation method could help them choose the pertinent model.

Based on the work of Bernard Walliser [Walliser, 1977], each model holds a set of characteristics. The characteristics of a model are syntactic, semantic and pragmatic. The modern usage of these terms was attributed to Charles Morris (1938), who first distinguished three branches of inquiry in language studies: syntactic, semantic and pragmatic.

Syntactic characteristics are related to the grammar used to build the model and the specific primitives of the semi formal language used. They include:

- Clear grammar structure: Being able to write down the model's grammar is a way of proving the coherence of the model and its robustness. And the robustness of the model
- Saturation [Bernard Walliser. *Systèmes et modèles, Introduction critique à l'analyse de systèmes,*]: the set of primitives offered to build the model are sufficient to depict enterprise systems studied, that is to say there is no redundant primitives that can be deduced from another one. The model displays pertinent primitives which use is clear and know to user (in our case enterprise management staff)

Semantic characteristics are related to the way the model is understood it includes the fact that the model have to be:

- Simple [Walliser, 1977] : "the number of hypothesis or steps made into the model have to be as simple and reduced as possible" [Walliser, 1977]. This characteristic is extracted from the "parsimony's principle" of Okham [Alféri, 1989.]

- Exhaustiveness [Walliser, 1977]: To avoid being misunderstood, we prefer to use genericity, as this characteristic is not meant to have a model that depicts all of the possible cases but it underlines the ability of the model to depict at least more than a single system. It is not, hence, built specifically to an enterprise system.

Pragmatic characteristics are mainly related to the understanding of the model by its interpreter. They consist of:

- "Sensibility" [Walliser, 1977]: the model has to be precise enough to report different cases in different models. If the studied enterprise changes the model should be "sensible" enough to report this change to its user.
- "Suppleness" [Walliser, 1977]: As the systems described are under constant change, the model has to be easy to change and offering re engineering qualities to accompany an enterprise through its evolution.

By proving that a model has these different characteristics, we validate the structure of the model. We will have to validate, then, its use through the validation of its different function.

After studying various types of scientific models (dealing with different systems also), Walliser [Walliser, 1977] identified different functions for a model: normative function, decision- making function, cognitive function...

As we are orienting our work to help management decision making, we have to prove that the SCM models, CRM models and finally the PLM model build are having three specific functions: the decision- making function, the cognitive function and the descriptive function.

- The decision making function is consists of "fixing control variables to reach the needed output variables taking into account the evolution of external variables" [Bernard Walliser. *Systèmes et modèles, Introduction critique à l'analyse de systèmes,*]. An enterprise model is meant to facilitate decision making.
- The cognitive function emphasizes the role of knowledge into enterprise modelling. The model has to facilitate the understanding of the system and knowledge acquisition, it "depicts internal relationship between input and output variables". [Walliser, 1977]
- The descriptive function or the representational function completes the cognitive function. Before depicting the relationship between different variables the model has to define the type and role of all variables used, it has to depict accurately the system to allow a good understanding of its functioning and uses.

Besides these three common functions each enterprise model proposed has specific functions related to the domain it is used in: SCM, CRM or PLM. After determining these different functions through a literature review and case studies in practice, we will run a functional analysis for each discipline to validate the large set of function of each model studied and though validate the model.

6- Conclusion:

Enterprise modelling is proposing a variety of tools that addresses different enterprise aspects: the functional aspects, the data/information aspect and the resources aspect.

Process coordination could be a good way to have an integrated view of these aspects. We focused though on three core business processes: SCM, CRM and PLM. Because of their knowledge characteristics, we added KM models to our proposed integrated enterprise model.

But when getting to study closely enterprise models under this specific vision, we come to notice that PLM models are scarce, compared to SCM and CRM models, and do not contain all the PLM concepts. Most of these models are adapted especially to specific enterprises and are, though, difficult to reproduce in other cases.

7- References

- [A] Alféri Pierre. Guillaume d'Ockham le singulier. Les Editions de Minuit, 1989.
- [AC] Arnold, J.R.T., Chapman, S.N., 2004. Introduction to Materials Management. Pearson Prentice Hall, New Jersey
- [AP] Avlonitis George J., Panagopoulos Nikolaos G.. Antecedents and consequences of CRM technology acceptance in the sales force. *Industrial Marketing Management* 34 (2005) 355–368
- [AR] Abdulmalek Fawaz, Rajgopal Jayant. Analyzing the benefits of lean manufacturing and value stream mapping via simulation : A process sector case study. *International Journal of production economics*, n° 107, 2007.
- [AS] Abramovici, Michael and Sieg Olaf C. Status and development trends of Product Lifecycle Management. *Product Data Management, Product Lifecycle Management, Product development, Digital Engineering, Engineering Collaboration*
- [BE] Boughzala Imed & Ermine Jean- Louis. *Management des connaissances en entreprise*. Lavoisier , 2007
- [CT] Chiang Tzu-An, Trappey Amy J.C. Development of value chain collaborative model for product lifecycle management and its LCD industry adoption. *Int. J. Production Economics* 109 (2007) 90–104
- [D1] Debeacker Denis. *Product Lifecycle Management*. 2002
- [D2] De Marco T. *Structured analysis and system specification*. ACM Classic Books Series Classics in software engineering 1979
- [D3] Dilworth, J.B., 2000. *Operations Management*. Dryden Press, Orlando
- [D4] Donlon, J.P. Maximising value in the supply chain. *Chief Executive* 117, 54-63, 1996
- [DV] Doumeings G., Vallespir B., Chen D. GRAI grid, decisional modelling, in: P. Bernus, K. Mertins, G. Schmith (Eds.), *Handbook on Architecture of Information System International Handbook on Information Systems*, Springer, Berlin, 1998.
- [E] Eymery Pascal. *La stratégie Logistique*. Que sais-je, 2003

So we tried to propose a PLM model based on a wide literature review and search for PLM models. We identified the components of a PLM vision and translate these components into a semi formal language using redundant primitives in PLM models found in the literature.

Models validation is an important question that we are aiming to answer to in the next step of our research. Not only, have we to prove the validation of our proposed PLM model but we should, also, build a validation methodology to evaluate SCM, CRM, PLM and KM models and helps decision making to choose the most suitable model to apply in an enterprise.

[GS] Global Supply Chain Forum (GSCF): ou connue avant pour le “Research Roundtable of the International Center for Competitive Excellence, de l’Université de la Floride du nord

[II] IIT Force. GERAM: Generalised Enterprise Reference Architecture and Methodology. 1999

[JK] Jun Hong-Bae, Kiritsis Dimitris, Xirouchakis Paul. Research Issues on closed loop PLM. *Computers in Industry* 58 (2007) 855–868

[KB1] Kalpic Brane, Bernus Peter. Business process modelling in industry- the powerful tool in enterprise management. *Computers in Industry* 47, 299-318, 2002.

[KB2] Kiritsis Dimitris, Bufardi Ahmed, Xirouchakis Paul. Research issues on product lifecycle management and information tracking using smart embedded systems. *Advanced Engineering Informatics* 17 (2003) 189–202

[KV] Kosanke K., Vernadat F., Zelm M.. CIMOSA: enterprise engineering and integration, *Computers in Industry* 40 1999.83–97

[LC] Lambert Douglas M, Cooper Martha C. Issues in Supply Chain Management. *Industrial Marketing Management* 29, 2000

[L] Liebowitz Jay. *Knowledge Management Handbook*. CRC Press 1999

[M1] Macintosh Ann, *Artificial Intelligence Applications Institute*, University of Edinburgh

[M2] Magretta, J. The power of virtual integration: an interview with Dell computers’ Michael Dell. *Harvard Business Review* 76, 72-84. 1998

[M3] Magretta Joan. Why Business models matter? *Harvard Business Review*, 2002

[M4] Melan EH. *Process management. A systematic Experience*. Springer 1993

[MM] Menzel Christopher & Mayer Richard J The IDEF family of languages.. University of Texas. www.idef.com

[MS] Mehtälä Mari, Still Johanna. A Cross-Functional Process Framework for Customer Knowledge Management. University of Oulu, Department of Marketing

[PS] Parvatiyar, A., & Sheth, J. N. (2001). Customer relationship management: Emerging practice, process, and discipline. *Journal of Economic and Social Research*, 3(2), 1–34

- [R] Ross D.T. "Structured Analysis (SA): A Language for Communicating Ideas," IEEE Transactions on Software Engineering, vol. 3, no. 1, pp. 16-34, Jan/Feb, 1977
- [RR] Rigby, D. K., Reichheld, F. F., & Schefer, P. (2002). Avoid the four perils of CRM. Harvard Business Review, 80(2), 101–109.
- [S] Stark, John. Product Lifecycle Management. 2006.
- [SF] Sudarsan R. , Fenves S.J., Sriram R.D, Wang F. A product information modeling framework for product lifecycle management. Manufacturing Systems Integration Division. Computer-Aided Design 37 (2005) 1399–1411
- [SS1] Srivastava, R.K., Shervani, T.A. & Fahey, L. Marketing, business processes, and shareholder value: an organizationally embedded view of marketing activities and the discipline of marketing. Journal of Marketing, 63(Special Issue 1999), 168–179
- [SS2] Suhong Li, Subba Rao, Ragu-Nathan T.S, Bhanu Ragu-Nathan. Development and validation of a measurement instrument for studying supply chain management practices. Journal of Operations Management 23, 618-641, 2005
- [T1] Terzi Sergio. Doctoral dissertation : Elements of Product Lifecycle Management: Definitions, Open Issues and Reference Models. Public discussion on 27 May 2005
- [T2] Terzi Sergio, Cassina Jacopo, Panetto Hervé .Development of a Metamodel to Foster Interoperability along the Product Lifecycle Traceability, in Interoperability in Enterprise soft wares and applications, Springer London 2006
- [V1] Vernadat François. Entreprise modelling and integration: principles and application, Chapman & Hall, London, 1996,
- [V2] Vernadat François. Techniques de modélisations en entreprise : Applications aux processus opérationnels. 1999
- [W] Wines L. High order strategy for manufacturing. The Journal Of Business Strategy, 17 (4), 1996
- [Z] Zablah, A.R., Bellenger, D.N. & Johnston, W.J. (2004). An evaluation of divergent perspectives on customer relationship management: Towards a common understanding of an emerging phenomenon. Industrial Marketing Management, 33(6), 475–489.