INTERNATIONAL DESIGN CONFERENCE - DESIGN 2008
Dubrovnik - Croatia, May 19 - 22, 2008.

A PLM APPROACH INTEGRATING ULM (USAGE LYFECYCLE MANAGEMENT)

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Keywords: ULM (usage lifecycle management), PLM (product lifecycle management), product and service innovation

1. Introduction

Today, economic, social and politic context implies more and more constraints on the manufacturing industries. To succeed in this worldwide competitive environment, companies must offer new possibilities and opportunities to their clients. Customers need more and more technological products and high level of services. Therefore industrial companies focus their efforts on innovation and design processes to satisfy these requirements. The aim is to develop products and services with relevant added value according to the customers' needs. In order to define this added value for each client, it is interesting to focus on the "usage" of products and services. Today, usage dimension appears as a socio-technical solution to improve design and innovation. Usage defines product/service utilisation related to a specific context. Thus, usage information is central feedback to find new functions of future products. But products complexity and short time to market imply several difficulties in design process. The development of product implies the collaboration of many different experts focusing on each phase of product lifecycle. To ensure the company success, it is necessary to have a powerful information system to integrate all constraints and modifications in design phase. Collaborative design engineering based on PLM (Product Lifecycle Management) systems address this integration problematic. These tools provide functions to support project structuring, product data exchanges and information sharing management.

This paper focus on ULM approach development (Usage Lifecycle Management). We propose in the first section new concept explanations. Then, we focus on our research works on a system dedicated to the management of product usages. The third section describes the correlations between ULM system and a PLM tool through an experimental analysis deduced from an industrial case study.

2. Integrating "usage" into PLM approach

The challenge of our research work is to develop a system to manage information related to different usages of products and services. This information on usages is coming both from customers and from stakeholders of design and manufacturing processes inside companies. This concept arises from our fieldwork analysis within a multinational aeronautical company and from a state of the art analysis on integration of the usage thematic. In the following sections, we describe these two points to characterise our scientific approach.

2.1 Industrial context

Our research activities are funded by the European project named SMMART (System for Mobile Maintenance Accessible in Real Time). SMMART is a research project oriented on MRO (Maintenance Repair and Overhaul) approach. The objectives of SMMART are to improve logistic and traceability processes in maintenance activities in aeronautic and automotive sectors [Blaszkowska 2007]. In this project, our tight collaboration with an aeronautic partner, who enabled us to identify industrial problematic related to usage. We focus on communication difficulties and integration challenge in multinational company.

In our introduction we deal with competitive context and innovation needs to succeed in current economic environment. For instance, in SMMART project, the goal is to implement new control system on product to have a real time feedback about products use. RFID (Radio Frequency Identification) tags coupled with wireless sensor are developed to send data via satellite. All data will be centralised in a worldwide central database.

Despite the fact that today information systems are very powerful, it is difficult to collect and reuse in design process relevant information coming from users and maintenance operations. This phenomenon is amplified in multinational companies because front office departments and users are very scattered. Multiple information flows and databases involve difficulties to manage homogeneous and interconnected information related to products uses that have been launched on the market. However, it is crucial for the design process to have clear information on existing usages to develop innovative products. Currently, usage feedback information available at early design phases is not sufficient and remains mostly technical information [Legardeur 07]. Thus, the industrial problematic can be formalised as "How to increase information availability related to product usage in order to improve the level of innovation in future products?". In order to address this problem, we will present usage thematic in the next paragraph.

2.2 Usage thematic

In research, usage thematic appears in the 90's. Today, usage capitalisation interests famous companies (Dell USA, Sony, Philips…) to bring added value in innovative design. Usage is closer to human factor research and is the genesis of user's oriented approach to develop R&D [Veyrat 2008]. There are many methods around user's oriented approach. Human engineering approaches and "User centered design" [Quaranta 1994] are focused on comfort, usability and esthetical aspect [Sagot 1998]. Human engineering approach improves product utility and usability. Utility is defined as "ability to help user to succeed in his objective". Usability is defined in ISO 9241 as "the degrees according to which product can be used by identified users in order to succeed objectives with efficacy, effectiveness and satisfaction in specified context". Some author highlight that human engineering and user centered design are too limited [Branguier 2004], [Valette 2005]. Indeed, in order to have a global vision and complete knowledge about usage information, it is primordial to take into account utility and usability of product in relation to utilisation context and user's habits. Through an observation on field, it is possible to capitalise usage coming from customer. This work enables designers' team to improve their collaboration and to take into account customer's requirements at several organisation levels as shown in figure 1.

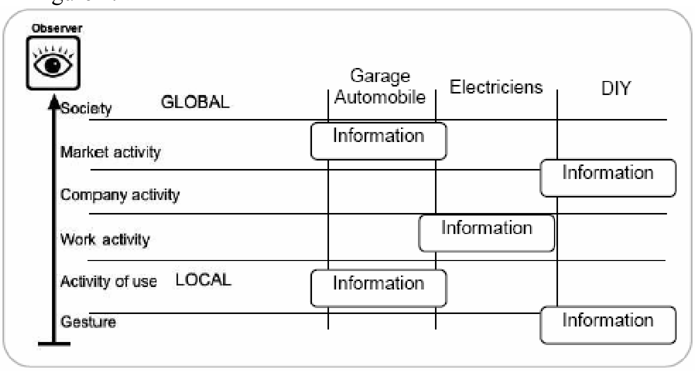

Figure 1. Usage information cross table from local to global level. GLOCALE approach [Valette 2005]

2.3 PLM approach

PLM consists in a strategic approach of information management related to the product, from its definition to the phases of manufacture and recycling. The PLM concept holds the promise of seamlessly integrating all the information produced throughout all phases of a product lifecycle to everyone in an organisation at every managerial and technical level, along with key suppliers and customers [Sudarsan 2005]. Such considerations allow making concrete improvements in terms of reduced time to market, improved product quality, reduced prototyping costs, stock management, traceability of information flows for better re-use and savings through the complete integration of engineering workflows, etc. Since the PLM takes into account all the activities of the product lifecycle (product conceive, design, manufacture, exploitation, etc.), it leads to assist all the decision-makers implied in these activities, whatever the level and the type of this decision.

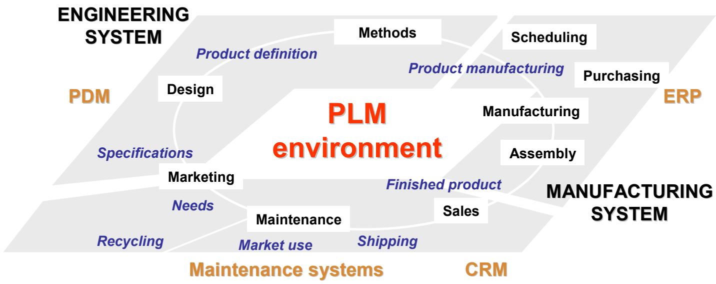

Figure 2. Product lifecycle and PLM tools

So PLM has a significant role in the management of the design system of a company. Hence competitiveness of the company is dependant on a jointly evolution of the products and the system itself, which is carried out according to requirements of the market.

Nowadays with the evolution of their functionalities, PLM systems become a federative kernel of interoperated systems that cover all product development phases: not only CAD/CAM and CAE systems but also ERP systems, CRM tools or Maintenance Management systems according to the company needs (figure 2). Such complex PLM systems manage all the elements of the product data numerical chain [Saaksvuori 2004] during long periods.

Focusing on the use phase of product lifecycle by customers, maintenance and customer-oriented departments have the opportunity to establish fruitful relationships with customers and third party actors interacting with the product. The aim is to get a feedback on the usage of the product and to integrate such information into the PLM system of the company in order to re-use it for predictive maintenance, product improvements or new products developments.

3. A tool for managing "usage" from maintenance to design

After our research perimeter definition, we establish in this section usage analysis and experimental study. First of all we characterise usage in order to develop case study in a PLM tool. This experimental study determines process flow according to specific usage case.

3.1 Towards a "usage" modelling

The difficulty in usage modelling is to cover the multiple usage cases. As mentioned in 2.2, usage can be distinguished into 3 sub-definitions, utility, usability and user's habits. Utility and usability refer to product functions definition in order to satisfy user's goal. As regards, habits refer to utilisation context, user's skills… Unfortunately, customer habits identification implies field observation in live with an observer or cameras system. It's simply to understand that observation is hard to implement in multinational or directly to customer home. Too many constraints appear such as confidentiality or budget deployment. Our objective is to capitalise usage information without field installation. Today, we wish to capitalise usage information "semi-automatically". In our approach, we choose to characterise usage with Product/User/Environment tryptich. In figure 3, we try to decompose usage according to User, Product and Environment constituents.

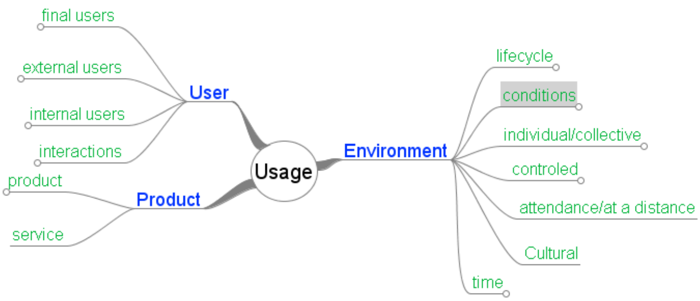

Figure 3. Usage decomposition

This characterisation is dedicated to help users in their usage cases definition. The aim is to define usage related to user categories, to product type and to utilisation context:

- **User**: we distinguish 3 users' communities. Firstly, user can be a customer (final user). Their needs should totally take into account to ensure their satisfaction and loyalty. Secondly, user can be an external user such as a retailer. This kind of user has a different view related to product and can bring relevant information about logistic for instance. Finally, we do not forget internal users who represent employees. In our research perimeter, we focus on employees from downstream product lifecycle; this is to say maintenance and recycling processes.
- **Product**: product is not necessarily a physical product which is directly in interaction with user. Software is considered as product but it is not directly in physical interaction with a user. Thus usage can be defined differently. We consider also services that can represent specific usage.
- **Environment**: usage depends also on utilisation context. The usage view is different according to lifecycle processes. Customer has not the same usage than a maintenance technician in a support process. We can mention also environmental conditions (climatic, sanitary, normalise). Product use depends also on the frequency of its use. For instance usage is not the same if a camera is disposable or unlimited in utilisation.

This usage characterisation tries to cover all constituents describing interaction between User/Product/Environment. This decomposition should be implemented in a tool to help for usage information capitalisation.

Thanks to usage capitalisation, we see 3 possibilities of exploitation:

1. Feedback on problems detected in utilisation/maintenance/recycling processes. Thanks to sales service and quality control, usage information can be defined as a problem. This point implies a modification request to design team (experimental case in this paper).
2. Usage feedback from utilisation/maintenance/recycling to design. This solution enables to re-design product if product does not satisfy users. This approach refers to experience feedback and permits to minimise time to redesign.
3. Usage feedback from utilisation/maintenance/recycling to early design phases in order to define news ideas. It is innovative design.

3.2 Proposal of ULM tool

ULM system is specified to cover the downstream product lifecycle phases. ULM systems connected with ERP and PLM systems become a new strategic approach in the scope of PLM approach. ULM objectives are to capitalise, to formalise and to reuse usage information to re-design or identify news ideas to innovate. Currently, famous companies such as Dell USA or Sony focus their interest on

users' forums. Forums are big source of relevant usage information to improve products and innovate. This trend is named innovation via usage or bottom-up innovation.
We wish to develop a tool either plug in PLM solution or plug in a PLM tool as additional function. ULM tool will be decomposed into 3 phases: user connection, user classification and ULM functions. At first connection, users should detail their usages thanks to usage characterisation (3.1). The usage description for each type of user enables to create a user community in each user group. ULM functions are composed of 5 main functions: History, Intervention request, Improvement request, Ideas box and Forums. The concept "History" is similar to "product lifecycle card" one. Indeed, user has to check owner information, products, accessories, failures occurred, improvements... "Intervention request" is dedicated to help user to formalise failure or problem events. "Improvement request" helps user to point out the need of improvement of a specific part or sub-system of the product. "Ideas box" enables users to submit an idea to improve downstream lifecycle product processes. Finally "Forums" enables users in same community to share their feelings about the product.
Figure 4 introduces possible architecture of ULM tool. We distinguish 3 communities of users, as mentioned in 3.1: customers, internal users and external users. All usage information, coming from the different users, will be stored in specific ULM database. A new role will be created to manage and analyse usage information. This analyst must be a designer in order to have necessary knowledge about product design.

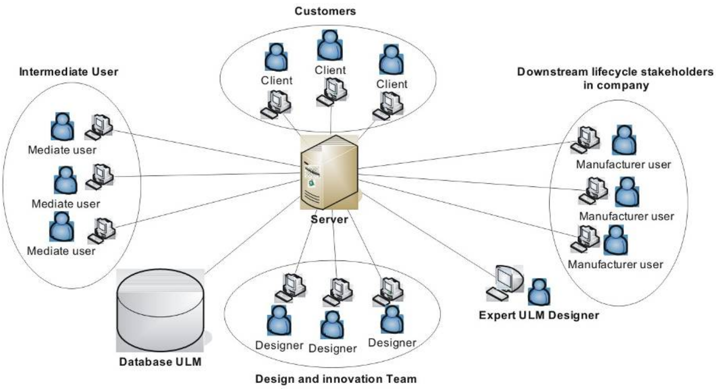

Figure 4. Architecture of possible ULM tool

This ULM tool aims at minimizes the distance between customer/maintenance employees/recycling employees and designer team. This gap is at the origin of many misunderstandings in needs definition. ULM tool promotes collaboration between the different users to capitalise, formalise and reuse usage information so that designers redesign and innovate better.

4. Experimental case study

Different situations of reusing usage information have been introduced in 3.1. As a first experiment, the usage formalisation by maintenance department is studied through management of occurring incidents and integration with existing PLM system is evaluated.

4.1 "Usage" management into a PLM system

In maintenance department of our aeronautical company partner, a manual procedure based on worksheets is used to compile a list of incidents occurring to each part of their product. It identifies significant problems in order that the design department brings improvements according to their critical level and their frequency.
We are able to identify a theoretical "maintenance to design" process that will formalise usage from the maintenance point of view, its management through a virtual ULM tool then a PLM tool. This process is described by the following steps:

"Intervention request" management into ULM system:

1. capture of usage information,
2. identification of significant cases and transfer to PLM system,

"Redesign" management into PLM system:

3. characterisation of "sets of significant cases" for product improvement study,
4. management of design process for improving the product,

"Update of product data":

5. design changes broadcasting from the PLM system into all company's systems managing product information (maintenance system, ERP system, ULM tool…).

The experiment aims at validating the feasibility of supporting this process through the combination of ULM and PLM tools. Actually the ULM tool is still a proposal. As a consequence the experiment, based on the same PLM system as the company (Windchill - PTC), assumes that a possible connection may exist between them in the future to automate the identification of maintenance problems and their transfer into the PLM system for their reuse by designers to improve existing products. As a consequence, steps 1 and 2 are simulated directly on the PLM system. For the same reason, step 5 is not implemented.

Two main aspects are considered: the characterisation and the management of usage information, and the management of the "maintenance to design" process.

Considering the first point, usage information is formalised by:

- an incident worksheet, in order to trace problems identified by product users;
- a set of significant cases which groups together several incidents dealing with similar topics.

Figure 5 illustrates the definition of an incident worksheet with the links to product data corresponding to the concerned sub-system of the product.

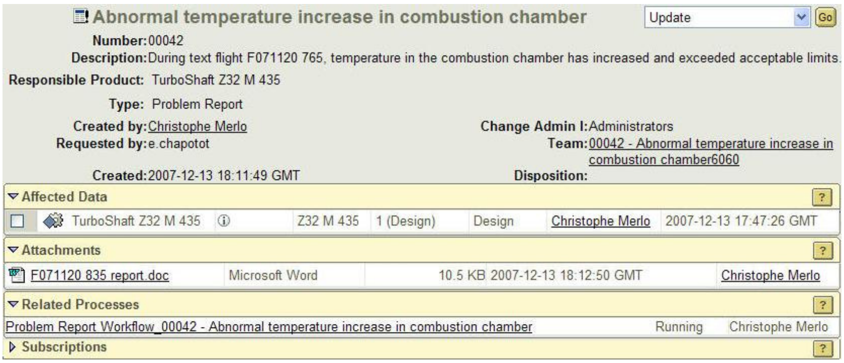

Figure 5. Integration of a problem report example before a Change Request creation

Considering the management of the "maintenance to design" process, it is implemented by using 3 consecutive workflows (figure 6):

1. formalising usage knowledge (simulated):
   - formalisation of usage knowledge (incident worksheet) by maintenance engineers,
   - validation of such knowledge by maintenance manager,
   - identification of a set of incidents by maintenance experts.
2. validating a set of usage knowledge for product modification (real test, figure 6):
   - generation of a product change request by the product manager based on the received set,
   - validation of the change request by a design expert,
   - generation of a change notice that describes the modifications to be done on the product and that is sent to the designer in charge of the redesign (co-ordination designer).
3. finally managing the redesign process to take into account previous set (real test):
   - dynamic definition of the design tasks schedule to apply and of the designers allocation by the co-ordination designer,

- achievement of the scheduled tasks by the designers as a sub-process,
- and validation of the design by the co-ordination designer, the product manager and the maintenance manager.

Figure 6 illustrates the whole process.

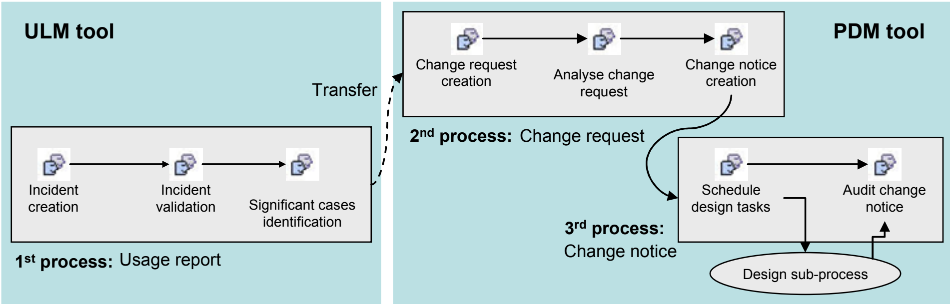

Figure 6. Incident management from ULM tool to PLM system

The workflow functions available within the used PLM system allow controlling these 3 predefined workflows, to define dynamically new tasks during the design sub-process and to synchronise the 3 resulting processes through the management of the states of the associated driven documents.

4.2 Synthesis

This first experiment is based on the implementation of existing functionalities of the chosen PLM system. It shows that such a system allows managing a specific skilled knowledge - e.g. usage knowledge from maintenance department - and that it is possible to extend it to the other possibilities of usage exploitation. By this way the whole process from problems identification to the validation of a new official version of the product is completely automated and driven through workflow engine. Collaboration between internal actors is fostered in order to improve product development: e.g. different roles and users can be dynamically assigned into a project; information can be shared through documents…

Nevertheless the limitations of the experiment are due to the technological limitations of a PLM system. First the 3 workflows are predefined and they cannot be modified when started. The design sub-process is defined dynamically but cannot be modified also when started. The roles associated to the tasks are also predefined. This situation limits the possibility of being flexible during the management of the whole process. Moreover the PLM system does not manage the collaborative tasks between the different users and this is a strong restriction during early design phases. The emergence of an innovative process is one the main requirements for the ULM tool.

On the research aspect, most of the work still remains: this experimentation has explored only one of the three possible ways to re-use usage knowledge. Further work will be to define a detailed and complete knowledge model to manage usage knowledge, then to specify the required functionalities and interfaces for all types of users.

Moreover the definition of an ULM tool is a localised solution but must be seen at a more global level considering the complexity of the heterogeneous and to-be-interconnected systems of a company. In a PLM perspective all product configuration documentation must be updated through all existing systems managing product information. The ULM tool impact will be increased by implementing interoperability between it and PLM system and between PLM system and other systems.

5. Conclusion

In a worldwide competitive market, product usages on the market are a rich source of knowledge for designers. In this paper usage concept is explored and situated in the PLM approach. Then we propose an ULM (Usage Lifecycle Management) tool for managing the usage capture from both end-users and expert actors. This tool is illustrated through an industrial case study based on maintenance

stakeholders' reports. This example shows how maintenance knowledge about usage may be re-used through a PLM system by designers to improve the product. This work is an introduction to next steps which will consist in modelling usage knowledge and specifying a ULM tool.
We consider that the development of a specific tool in line with the context of a company is still for the moment a good perspective to foster new ideas taking into account usage dimensions. On the other hand the implementation, the test and the integration of such a specific tool in a company generate many problems. Specific tools are studied and implemented as prototypes or demonstrative tools. So lacks are generally present concerning database management, information control, user rights, software robustness, management functions [Merlo 2004]... Their implementation is made in a research context and the industrialisation and maintenance aspects are not taken into account. Moreover the integration of such tool must be linked to the existing systems in a company in order to propose an integrated environment. So in future work our objective is to study the integration of a specific tool into a PLM system and to manage interoperability problems.

Acknowledgement

This work was carried out within the SMMART (System for mobile Maintenance Accessible in Real Time - www.smmart.eu) project that received research funding from the European Community's FP6.

References

Blaszkowska, P., Pieriegud, J., Wolanski, M., "Logistics traceability for su pply chain improvement. Case study of SMMART Project", Proceedings of ICEIS'07, 9th International Conference on Enterprise Information Systems, Funchal, Portugal, 12-16 june 2007, pp 599-604.

Branguier, E., « La boucle usage adaptation-reconception : l'usage comme intégration des points de vue de l'utilisation et de la conception », 39ème congrès de la SELF, Ergonomie et Normalisation, 2004, pp535-543.

Legardeur, J., Merlo, C., "Fostering creativity and innovation during early informal design phases. Part 1: sociotechnical and psychology studies", Journal of Design Research, Vol. 6, n°1, 2007, pp.1-4

Merlo C., Legardeur J., "Collaborative tools for innovation support in product design", in the proceedings of the 8th International Design Conference, Design 2004, pp. 787-792, Editor D. Marjanovic, Dubrovnik, 18-21 May, 2004.

Quaranta, D., "Eléments de design industriel", Polytechnica, 1994.

Saaksvuori, A.., Immoen, A.., "Product Lifecycle Management", Springer-Verlag, Berlin, 2004.

Sagot, J.C., Gomes, S., Zwolinsky, P., « Vers une ergonomie de conception, gage de sécurité et d'innovation », in: International Journal of Design and Innovation Research, vol 1, N°2, 1998, pp 22-35.

Sudarsan, R.., Fenves, S. J., Sriram, R.D., Wang, F., "A product information modelling framework for product life cycle management", Computer-Aided Design, Vol. 37, n°13, 2005, pp. 1399-1411.

Valette T., « Recherche d'un cadre conceptuel d'aide à la conception collective innovante par l'usage : proposition d'un outil "Glocal" pour la conception d'outils à main et des équipements de travail », thesis of Ecole Nationale Supérieure des Arts et Métiers, 2005.

Veyrat N., "Les usages dans la lunette: co-concevoir des produits et des usages innovants", thesis of Pierre Mendès-France university, 2008.

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