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# MANAGING DESIGN SYSTEM EVOLUTION: A PARTICULAR APPROACH BASED ON CROWDSOURCING FOR THE USAGE LIFECYCLE MANAGEMENT APPROACH (ULM)

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## ABSTRACT

Today the success of companies depends on their ability to design innovative products. This point implies to manage not only product/process data to follow design system evolution but also to foster interactions and control the collaboration among the different stakeholders involved in the different design projects. In this paper, we define the performance indicators which are impacting the performance of the design projects. They are changing all the time and provide an evolutionary vision of the system. They could be identified in the system or during the upstream or downstream phases of the product lifecycle. Especially we focus here on the performance indicators of the downstream phases (utilization, maintenance, recycling). We propose the UML approach (for Usage Lifecycle Management) to manage product information related to product usage context. This approach is supported by an external platform collecting and valorizing usage information from the different stakeholders such as customer, retailer or employees. This web 2.0 platform is developed with a crowdsourcing approach to collect information in a multi-users, multi-products and multi-companies network.

*Keyword: Usage in Design, Performance in Design, Usage Lifecycle Management, Crowdsourcing*

## 1 INTRODUCTION

In the extended enterprise context, many stakeholders take part in the product development and design project management has to foster collaboration among all the people involved in the project. That implies a huge number of exchanges between partners and implies to manage a lot of information. Despite of the fact that information systems are very powerful, it appears that is difficult for all the stakeholders to have the good information at the right time. This phenomenon is amplified by the department disperse. The information flows (high level of quantity and complexity) and the multiple databases involve an information management not really effectiveness and optimum. Nevertheless, information management is a key success factor to reduce “lead time to market”, improve reactivity and innovation in companies. Indeed, during the design of new products, designers need to collect and reuse different kind technical data and information and in the extended enterprise context the feedback and the capitalization of these data and information are not sufficient or even inexistent. This lake of information since the beginning of the design project implies some mistakes in the product definition and the service development. During the early design phases the information available is partial with a lot of uncertainties [1] and generally it is complex to propose news ideas to innovate. Moreover, in the upstream design phases, information is often unclear and substantial whereas the quality and the quantity of information during these phases are essential to ensure a good product development. Our objective is to find a new way to bring more added value to help designers in their decision making process. To achieve our objective we have to define information that could be relevant at the early design phases and to provide concept and solutions to allow decision-makers and designer to have this relevant information. Thus, industrial problematic can be formalize as “How to increase the availability of information related to product in order to improve the time to design and its quality?” and “What kind of information can bring added value to product innovation and to keep leadership in a competitive market?”. In this paper, we postulate that we have to identify the design performance indicators to define relevant information for designers and decision-makers in order to increase design performance. As a consequence, we focus in a first time on the PLM epicycle view to identify factors influencing design and the information flows between them. Second, we propose a preliminary model to manage these factors and we focus on their description through out the system, from the actors to the enterprises network. Objective is to identify and manage specific factors impacting the performance of each entity of the system and interactions between then. As to consider and to define the model on the whole represent a considerable task, we choose to focus on the identification and the management of the downstream information through out the Usage Lifecycle Management approach. The management of the design project is study here regarding the usage studies. We detail the reasons why we choose the usage information management, we define the ULM approach and finally we illustrate this approach thanks to a collaborative platform development that regroups several users' community. Objective is to identify failures, potential improvement and new functions to future product design.

## 2 SYSTEM LIFECYCLE MANAGEMENT (SLM) IN THE EXTENDED ENTERPRISE CONTEXT

Co-ordination and control of design are part of a global approach for the development of new products that implies the need to identify the different situations occurring during the design process and the adequate resources to satisfy design objectives. The design situations are described by identifying components of the design activity and their relationships [2], [3]. In design project management, the control of the design process is defined as the understanding and the evaluation of these existing design situations to take decisions. These decisions will modify and improve the future process, according to design objectives given by customer specifications or the company strategy. In a nutshell, management of design projects is a decision-making problem to support designers in their activities and achieve an objective in a specific design context. This context has an influence on the project and refers to the environment of the enterprise (society, market, subcontractors, etc) and to its organization [4]. Influences of the context affect each entity of the organization. Sudarsan et al. [5] proposed a high level view of these influences in their adaptation of the Product Lifecycle Management (PLM) epicycle diagram from [6] (Figure 1). The PLM epicycle current view emphasis that many kinds of information have to be considered and managed to ensure a coherent multi-level project management adapted to each decision-maker at each decision-level. PLM (Product Lifecycle Management) is 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 organization at every managerial and technical level, along with key suppliers and customers [5]. Such considerations enable making concrete improvements in terms of lead 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. In such a context, PLM support needs to connect the product design and analysis processes to the production and supply chain processes, including: product data management (PDM), component supplier management (CSM), enterprise resource planning (ERP), manufacturing execution systems (MES), customer relationship management (CRM), supply and planning management (SPM), and others that will undoubtedly follow [7]. That implies PLM supports have to evolve and to be more exhaustive. The aim of our research is to propose models and software tool to obtain an extended PLM support managing the co-evolution of the product and the system. Our ambition is to work on the opportunity to make evolve models, approaches and tools from PLM to SLM (System Lifecycle Management). The SLM approach considers all the elements of the system influencing the design, their interactions and their co-evolution to establish the better context for decision-making. That obliges to capitalize, formalize and follow information about each entity of the system. This capture helps decision-makers to analyze and understand the as-is situation regarding to the collected information ("as-was" situation) and to evaluate the impact of its decisions by considering the possible evolution of the system (the to-be situation) [8]. To formalize information about each entity of the system we have to model the system. The following section presents preliminary concepts to model the system on the whole.

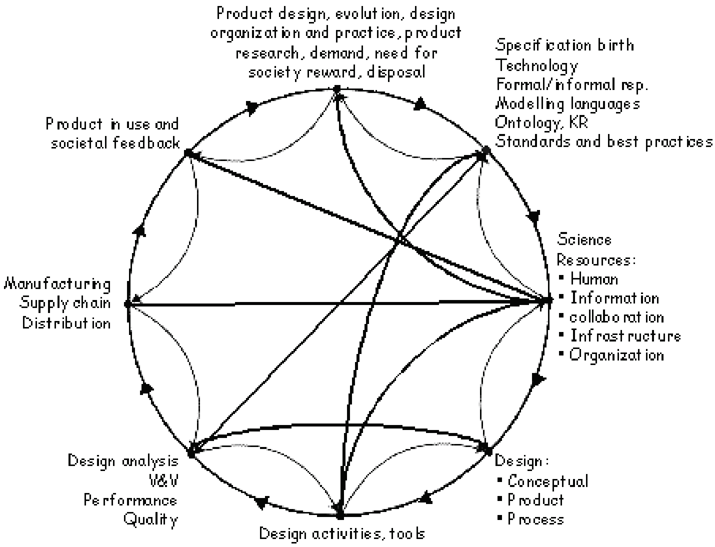


*Figure 1. PLM epicycle current view*

# 3 MODELLING THE SYSTEM AND ITS ENVIRONMENT TO MANAGE ITS EVOLUTION

## 3.1 Preliminary specification of system entities for system modelling

To make appear all the relationships between the different levels of decision-making, we have to define each entity of the system and their interactions. The system regroups many projects, is composed with many teams, many actors, many resources. Moreover, in the system, projects begin and finish at different times, teams are created according to the needs of collaborations, actors take part of the project for specific activities, they could leave the enterprise, etc. In a nutshell, all these entities of the system and their own lifecycle have to be considered to understand the current and the possible evolutions of the system. So, we proposed to decompose the system by considering the enterprise, the design system and the smallest entity of the system: the actor. The choice of the actor as smallest entity is justified by the fact that an actor is affected to projects, he works alone or in a team and he is in the design system, in the enterprise or in the other enterprises of the network. So, by focusing on the actor and factors influencing his evolution helps us to obtain a precise level of description of the factors impacting the design system and the enterprise. To take into account of the evolution of the system, we adopt a temporal view considering specific entities lifecycles.

### *3.1.1 Focus on the actor in the design system*

In the context of extended enterprise, actors could be implied in the design project or not, could be in the design system or not, in the enterprise or not but they are compulsorily in the network of enterprises. The customers and the society have also to be taken into account regarding to their influences on the design product evolution [9]. Factors influencing design performance concern in one hand the actor's activities (figure 2) and on the other hand the actor's context of evolution (figure 3). These activities have to be analysed regarding to the product, the process and the organizational viewpoints. The product view permits to show the actor's influence on the product. The models manipulated by the actor could be product or service models (designers), process or activity models (co-ordinators) or different kind of models (enterprise modelling, etc) depending on the actor's attributions in a project. These models and their evolution have an interest only if we capitalized also the context in which they evolve. That obliges to consider the activities that bring the model evolution (process view) and the project associated to these activities (organizational view). Considering evolution of these models permits to define the real and possible actor's actions on the models [10]. Models help to know what the actor has done, what he is doing and what he will be able to do on the product, in a given process and organization [11] that describe the actor's context of work. To specify the actor's context of evolution, we describe aspects from the actor himself to the system in which he has to work (figure 3). Some factors concerns actor's personal aspects and state of mind to help decision-maker understanding the actor to adapt his management style [12]. Far from personality, actor's knowledge is also a performance determinant. If we identify what an actor knows, what he has to know and how he uses his knowledge, we are able to provide to him tools, methodologies, physical supports or training courses to achieve properly his tasks and to increase its self-esteem. Finally, to express his personality and his knowledge, actor must be in "good conditions". Consequently, we have to trace his internal and external relationships to identify his "auto-organization" and to create a favourable collaborative context of work [13]. All these factors contribute to help decision-maker to optimize his management in the current projects but also in the future projects.

#### *3.1.2 The design system in the company*

Factors impacting performance of the design system are an aggregated vision of the lower description level (actor viewpoint) (figures 2 and 3). Managing information about each actor of the design allows building a global view of the design system. The partial product models of each actor designing this product are part of a more global product model in the design system. The aggregation (more or less complex) of the actors' activities permits to obtain a global vision of the design process model. And all the processes are parts of the design projects which are organized in the design system. These elements are local performance factors for the design system. Internal and external resources, knowledge are identified too. Internal and external interactions between these elements contribute to make evolve the model of the design system and favour performance of design process [14]. All these factors evolve with their own lifecycle and contribute to ensure performance of design [15].

#### *3.1.3 The company in the extended enterprise context*

Actors' evolution and evolution of the design system are also influenced by the enterprise, the network of enterprises and their interdependencies. The design actors, the design system are described and we focus here on the interactions between them, the company and the network of enterprises. Factors influencing design project at a strategic level have to be identified. That obliges to enlarge the notion of "project". Projects not only concern design project. Projects of the company may be financial or investment projects (buy a concurrent, find new financial partners), expansion projects (build new plants), partnerships projects (find new industrial partners), etc. A decision in one of these projects could affect design projects and could modify their evolution. Many processes composed these projects and could also impact the design. The results of these processes (products) could change the design product evolution. Consequently, the local performance factors (or determinants) concern these projects regarding to the product, process and organizational viewpoints (figure 2) and the global determinants describe the enterprise on the whole (figure 3). These factors help decision-makers at a strategic decisional level to know the situation of the company in term of resources' availability and capabilities, knowledge of the company [16], internal and external organization and its possible evolution [17].

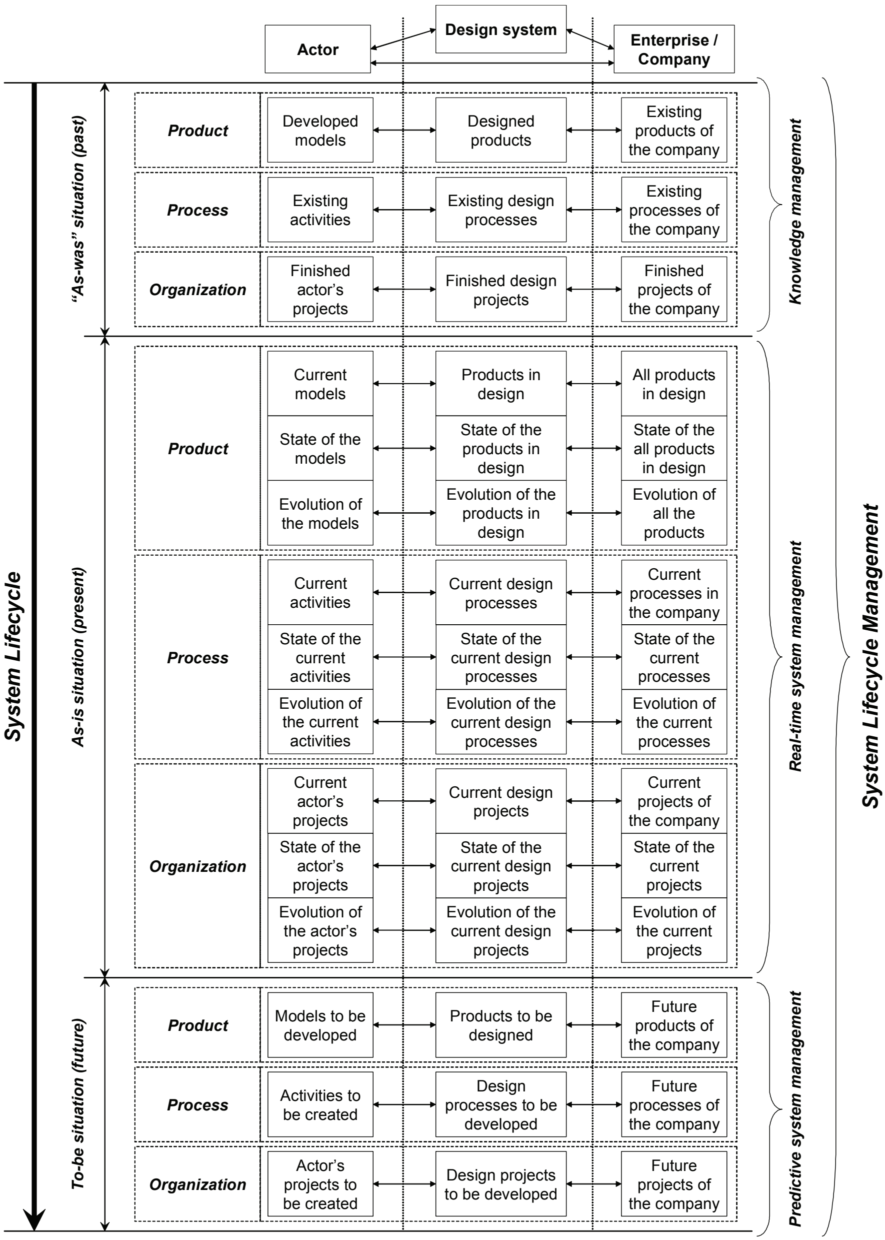


*Figure 2. Local performance factors influencing design*

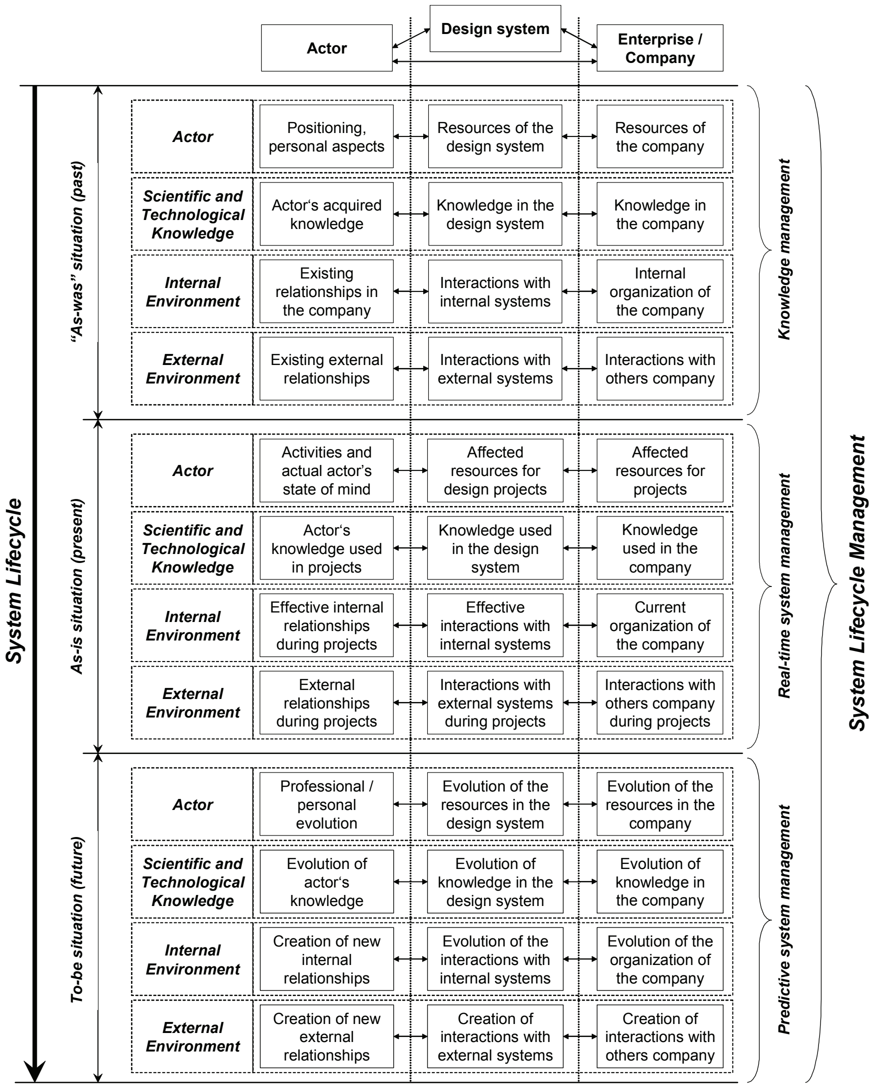


*Figure 3. Global performance factors influencing design*

The SLM approach and the two models above have been developed to identify, capture and share relevant information along product lifecycle. In the following section, we show it is possible to use this approach to study the information feedback from downstream lifecycle processes to design. We can find inside downstream lifecycle different kind of information. Related to economic climate and needs to innovate and stay ahead of competition, companies focus on usage information. Thus, we illustrate among SLM models a potential application with particular information: usage information.

# 4 USAGE INFORMATION IN SYSTEM LIFECYCLE MANAGEMENT

## 4.1 From "User Centred Design" to "Usage Information Management" in design

Usage studies are not a new trend in research. Usage is an evolution of many studies around human factor. In the past decade, only product flows were important to develop company activities [18]. It was the time to mass production. Gradually, the management of product flows was not sufficient and human acquired a central place in the processes of the companies. Human became an added value to improve design process.

First approaches handling to human added value were User centered design [19]. The human engineering approaches appeared and were focused on the comfort, usability and esthetical aspect [20]. Human engineering approach improves product utilization and ergonomics. Valette highlights that human engineering and user centered design are too limited [21]. Indeed, it's essential to have a global vision about usage by considering product utility and product usability. Utility is defined as "the 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 to succeed objectives with efficacy, effectiveness and satisfaction in specified context". According to Valette [21], usage is also established in relation with a utilization context and with users' us and habits. Thus, usage information coming from the downstream processes of the product lifecycle has to be captured, formalized and reused to increase performance of the design project. The downstream processes include utilization, maintenance and recycling and are the places where interactions between user and finished product occurred (product is considered here as physic product or not).

From now on, actual concepts and tools are essentially focused on the management of information or data coming from manufacturing and design processes. For instance current PLM approach manages efficiently Product Data Management processes (PDM), customer information (CRM) and employee's information (ERM) but only during the manufacturing and design phases. The information management is more efficient in middle part of product lifecycle (design and manufacturing). A lot of research works are leading to improve the decision making system lacks in PLM [22]. To make evolve PLM approach, to complete current product information with user perception and to increase the use of usage information coming from downstream product lifecycle, we propose the ULM approach. The figure 4 shows the limits of the PDM in PLM approach and the possible place of the ULM approach that aspires to cover downstream processes of the product lifecycle (utilization, maintenance and recycling phases).

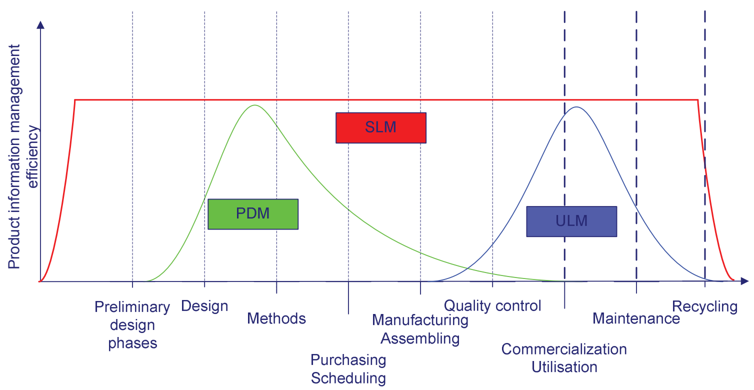


*Figure 4. Product information management efficiency related to lifecycle*

The ULM approach (acronym for Usage Lifecycle Management) has to permit and to encourage the use of the usage information from downstream phases in design and innovation processes, to help designer in decision making and to make easier product development. To better understanding, we suggest to detail ULM acronym as:

- "**Usage**" refers to product utilization by one or several users in specific context.
- "**Lifecycle**" refers to product lifecycle information management. In our works we focus on downstream processes where we find information about the finished product. These downstream lifecycle processes regroups commercialization-utilization, maintenance and recycling processes.
- "**Management**" refers to information management process. This loop includes capitalization

(collect process), formalization (structured information) and reuse of usage information. We focus on usage information capture. The capitalization of usage information is added value to product knowledge of companies.

ULM will provide added value to product and will engage innovate product development. ULM gives a human dimension to the current information management systems which are too techno-centred. When usage information is formalized and capitalized, it could be reused according to three ways:

- "**Failures exploitation**": the after-sales departments don't be pull away because it is at the origin of chronic problem detection that modify or stop product utilization. Thus, usage information feedback from downstream processes to design will launch quickly the partial or entire product redesign. Here, the objective is to improve company reactivity when product failures appear.
- "**Redesign exploitation**": when product performs normally, user can feel some annoyances and so give relevant usage information to companies. This kind of information bring added value to design process in order to improve product design even if it's commercialized yet. The objective is to iterate product so that perfectly satisfy user requirements.
- "**Innovation exploitation**": usage information collect could be at the origin of new functions, new ideas development. New needs identification leads up to innovative product development. Companies could propose product catalogue very close to user requirements and stay competitive in current market.

As the aim of this work is to provide solutions to consider customers requirements at each decisional level in the company we are developing a prototype of software tool to support the ULM approach.

## 4.2 A web crowdsourcing based platform to support ULM approach

### *4.2.1 External ULM platform*

Currently, user's requirements and their usage are generally collect by means of manufacturer website. Customer has possibility to register his product with serial number and give product characteristics. Today, these customer register systems are common to multimedia products as cellular, PC, laptops etc. We can access to product register function and customer monitoring in Dell and Sony website for instance. The current solutions propose by Dell (www.ideastorm.com) or Sony are not fully adapted and are too restrictive for several reasons.

First of all, manufacturer doesn't display clearly their objectives concerning usage information capture from customer. This solution appears as a solution to access directly to customer in order to know their habits and suggest product options. Customer assimilates this practice as marketing solution and not as fair exchange. However, these services lead up customer to give usage information about his own product. This information includes user and context in which product is used are difficult to capture. So as to obtain this information that implies to establish trust relationship with user. Although in the case of information capitalization made by manufacturer, this link not occurred.
Finally customer find this register system too restrictive and mostly haven't feedback about information entry. For these questions of confidentiality, trust and equity exchange information between customer and manufacturer are expected. Develop external platform is here a solution to attract user to share his product experience. The tool detachment of industrial background is highlight to lead up customers to share private information. External ULM platform can be assimilating to a communication bridge between users and manufacturer with common goal that is to think jointly future usage before design.

Finally, platform framework (figure 5) appears as platform place at middle way of different users. This platform is multi-companies, multi-users, multi-products. All usage information progressively supply database dedicated to product usage definition.

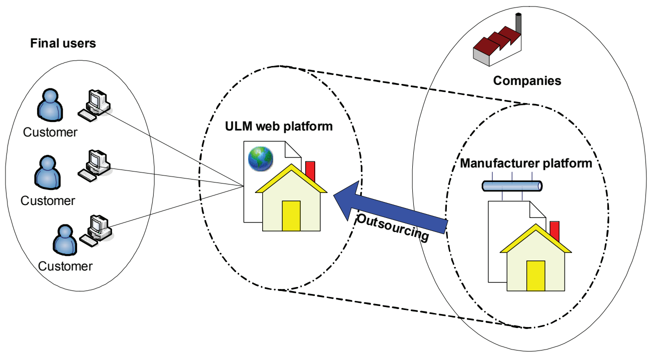


*Figure 5. ULM collaborative platform network*

#### *4.2.2 Implementation of the ULM collaborative platform*

This platform aims at capture and structure usage information related to many products and several users in order to improve design process and initiate new ideas.

In order to implement the database of our platform, we defined kind of data and information that have to be managed. Generally speaking, researches concerning the usage studies propose to define usage according three elements. For instance, Pierrault focuses on the user, the object and its functions [23] whereas Kinas studies object handling and utilization in activity context and he describes usage thank to user/product/context viewpoints [24]. According to this last usage characterization, we have defined 3 main elements that composed the trunk of platform:

**1. Users**: first of all, we consider many users types. Indeed, in order to cover usage information at different levels of product lifecycle, we take into account consumer (to cover utilization phase), companies and employees such as maintenance operators (to cover maintenance and recycling phases) and finally retailer (to cover commercialization phase). Information coming from all these users will be very different because they evolve in specific context.
For example, consumer uses his product every day with appropriate functions and could give usage information related to product design. Retailer has other point of view. For instance, packaging choose to product could be difficult to stock due to his format. Thus, retailer could be at the origin of packaging improvements with usage information sharing.
The first step to users is to create user account with login and password. This step identifies user's type among consumer (client), employee, retailer or manufacturer. We focus on user classification aim at assess for each user category the associate usage. Thus, we establish user cartography that contains user's information and their products. This user cartography identify user in community membership. Soudoplatoff shows the importance of user community where experience sharing occurred [25]. Community contains interest-based groups that engage and stimulate usage information sharing.

The major problem of this kind of platform is to motivate users to communicate and share information. Give usage information implies to discover a part of private life for costumer and part of work conditions for employees. That's why, it's very important to suggest equitable exchange between all stakeholders of the platform.
In order to attract companies to participate and give their vision about possible usage of own product, we envisage to give in first time sample of information coming from consumers. If this information appears interesting, we suggest agreements that engage share between companies within the platform. For example, we can suggest to companies a weekly report and different levels of statistics and usage information. This information enables manufacturer to reduce the gap between commercialized product and user's needs. Usage information could be at the origin of news functions or innovative products that cover future customer's demands.
Manufacturer can choose to integrate employees inside usage information capitalization. If it is the case, employees bring information about their work conditions. For instance, a maintenance operator has problems to change failed part in terms of accessibility. Thus, operator gives some information

about context and their problems with improvements solution. This information of accessibility could be integrate in design process to improve and facilitate maintenance activities and thereby reduce time to maintain.
To attract consumers, we choose to follow "crowdsourcing" scheme. [26] suggest an approach turn to innovation with the crowd. Crowdsourcing is a mix between open innovation and open source. We suggest to each participant to win points proportionally to their involvement in the platform. For example, for each connection 10 pts, problems underline = 100 pts, improvements suggestion = 200 pts, etc. A gift catalog could be available on platform to enable users to spend their points and give value to their contribution.

2. **Products**: second step is to identify product family and product characteristics. Thence, product identification completes user cartography. All products registered are stocked in ULM database. Progressively products information and users enhance this database.

3. **Environment/context**: for each product registered, user fills in usage form in order to describe conditions of utilization. Related to user category context and environment are different. For instance, retailer focus on packaging characteristics to put away finished product before commercialization. Retailer can bring usage information about quality of packaging. Customer has other view on packaging. Indeed for him quality of packaging depends on esthetical or robustness characteristics. When usage capitalization processes will be launch, the next step is to suggest at company to fill in usage form also in order to compare different users view with company. Compare usage forms lead to identify variation and satisfy better the user's requirements according to different utilization context (figure 6).

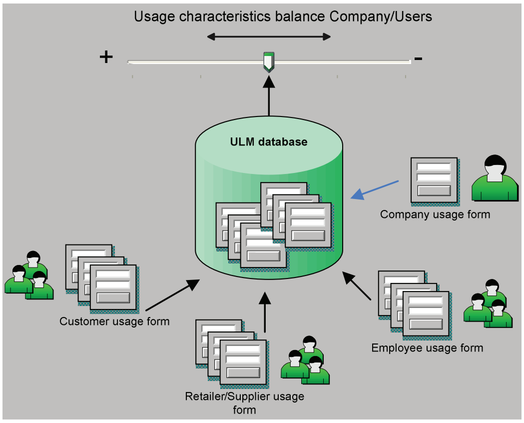


*Figure 6. Usage forms comparison step*

To identify and manage interactions between all these elements and their influences on the product design, we have study the integration of the ULM approach in the SLM approach. SLM considers the three elements (user/product/context) because of the fact they are included in the models. But we have also the notion of time and the notion of interaction between each element. That is to say that we are potentially able to follow the evolution of a usage in all the system. For instance, figure 7 shows the possible impacts of new information coming from a user. Our system captures the information and the company knows the information (1, fig. 7). This information will change for example a function on the product. As a consequence, the knowledge used in the project has to evolve to respond to the new objective (2, fig. 7). In the worst case, such a change could oblige to affect new resources and to make evolve organization of the project (3, fig. 7). The new organization has an impact on the interactions between the actors of the project and between each sub-system of the company (4, fig. 7). Finally, all these evolutions have an influence on the actors (5, fig. 7). In a nutshell, SLM approach allows us to model the system and possible information flows and ULM approach provides a dynamic view on the system by capturing information and deploying then in the system that will evolve.

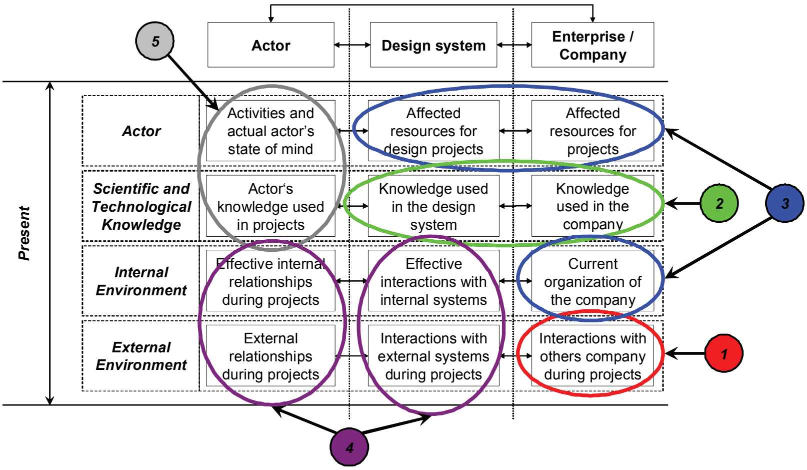


*Figure 7. Impacts of usage information on global factors influencing system performance*

## 5 CONCLUSION

Competitiveness of a company is dependant on a jointly evolution of products and systems, which are carried out according to requirements of the market. We have characterized factors that could influence the evolution according to the more or less significant changes that it implies on the system. From generic SLM models we show trough ULM contribution (Usage Lifecycle Management) a proposition to manage usage information in order to support decision-making during the product design process and to complete PLM strategic approach. Usage information brings more relevant information in design process and makes easier integration with other system as PDM, ERP, SRM (Supplier Relationship Management)… ULM brings another view of the relationship between customers and companies. It is not only based on contractual relationship with customer but also on existing or potential exchanges between users themselves and companies. The main vision here is to shift from the paradigm where the companies create products and customers buy this product toward a new business and usage model where the companies and the customers create together. In this new approach, the user's community can launch and discuss of new ideas and votes for the ideas to specify the products and collaborates with a company to industrialize them.

This work will be also used to develop PEGASE, a prototype of software tool supporting design actors during design process [27].

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