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COLLABORATIVE TOOLS FOR INNOVATION SUPPORT IN EARLY PRODUCT DESIGN PHASES: A CASE STUDY

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1. Introduction

Product design relies on complex technical and social processes. In previous work [Legardeur et al. 2001] we demonstrate that the early phases of product design projects can be suitable for the introduction of technological innovation. Indeed, designers sometimes have to work during pre-project periods in order to disseminate new ideas or new concepts and to introduce them as new product design innovations. In this context, the manipulated knowledge is emergent and not very well-formalised by the actors. So the co-operation processes are quite unstructured and the confrontation of the different actors' points of view leads to informal and unofficial information exchanges.

However actors do not always involve themselves spontaneously in the development of an innovation. The involvement in the innovation process relies on the ability of some actors to find allies and to promote the co-operation between them. These non contractual phases of discussion and negotiation are strategic to foster innovation which leads to the proposal of new solutions for product design.

In this context we have to study these informal mechanisms of co-operation to propose solutions that will support them. The aim of this paper is to propose an organisation of this information [Lowe et al. 2003] and an environment that will help to co-ordinate these informal processes [Baumberger et al. 2003]. We study how collaborative tools can structure informal exchanges among actors in order to introduce innovation in the early phase of a design project. This work is based on an empirical study made in the large company Renault VI specialised in industrial vehicles design and manufacturing. Then the configuration of a PDM system (Windchill Project link – PTC) is realised, as well as a specific collaborative tool called ID^2 (Innovation, Development, Diffusion). Finally we discuss about these two approaches and their limitations for supporting informal processes during early design phases and also for their integration in large companies.

2. Innovation in early design phases: a case study

We realised an industrial fieldwork based on a socio-technical study [Boujut and Tiger 2002] of the innovative process at Renault VI R&D departments. For over 18 months, we took part in the development of a new vehicle design project. This empirical study was the opportunity to observe closely the work practices of actors faced with a proposal for an innovative technical solution (and backed up by an expert supplier). The technical aspect of the design project was related to the development of a new application using a composite material (SMC i.e. "sheet molding compound") which was not very well known by designers. We were able to observe and analyse the collaboration processes between different kinds of actors. Our study [Legardeur et al. 2001] characterises the difficulties when a new material, different from the ones traditionally used, is integrated in a context where the actors do not produce a minimum of shared knowledge.

We included the material department of our partner to our field study by following and questioning specific actors, referred to as “materials experts”, who were also in charge of putting forward new ideas of product/process alternatives to the design offices during the pre-design stage. In these situations, the goal of the “materials experts” consists above all in managing a certain amount of tension between a “qualification” (or acceptance) system set up by the promoters of a new solution, and a “de-qualification” (or rejection) system implemented by the promoters of a more routine-based solution. New product/process ideas are thus developed during periods of negotiation and research, which are often informal and non contractual. At this level the official project has not been launched. The goal of these phases is first of all to be able to bring together a certain amount of data and information in order to justify and consolidate the idea put forward by defining the technical conditions that make possible to launch a new project. Within these processes the material actor has a very important and strategic role: first as a pilot actor and second by managing informal exchanges at *interfaces* according to [Finger et al. 1995]. The process of innovation acceptance relies on informal networks managed by a pilot actor and involving several actors from different departments and with different skills.

The observation of these informal processes lead us to formulate three hypothesis which characterise them:

- first, innovation requires an evolution of the organisation and especially the structuration of a network of actors around the points of view confrontation between the promoters of innovative solutions and more routine solutions,
- second, innovation implies the generation of new knowledge and its sharing between all actors involved in the proposal and validation of a new solution: the aim is to facilitate and to organise the emergence of this knowledge,
- third, innovation goes on with the development of new tools and criteria for the evaluation of product and process solutions.

By the way the confrontation between the different points of view implies large processes of informal exchanges. From this analysis specifications for a collaborative tool are defined. In order to foster innovation in these early design phases, we define key elements that should be satisfied and that are summarised as follows:

- support the creation of a network of actors around the material expert,
- provide a project guide for the pilot i.e. the material expert,
- enable the synthesis of different points of view in order to validate the proposed solutions,
- capitalise and re-use the information to assist future projects.

The collaborative tool must allow actors to formalise the proposed solutions and the related discussions. The collaborative processes combines information exchanges that can be categorised as questions, answers, negotiations and evaluations.

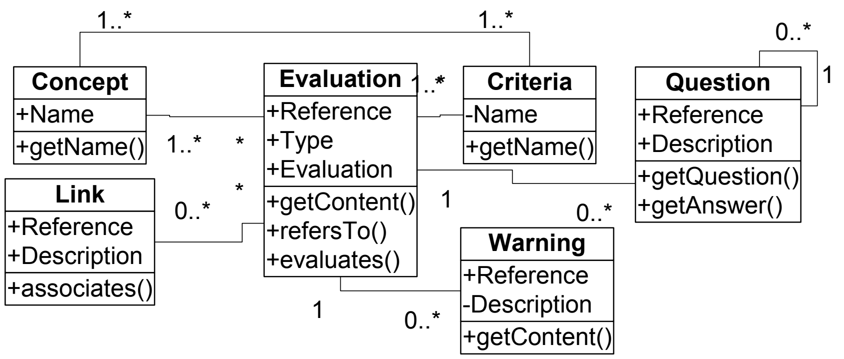

Figure 1. Class diagram for materials innovation support

Figure 1 represents the structure of information manipulated by the actors during a discussion: a “concept” describes a proposed solution; its “evaluation” is made for each proposed “criteria”. Actors can send “questions”, “warnings” or establish “links” to participate to the global evaluation of a “concept”. The whole process is seen as a project under the responsibility of the material expert. The material expert must define a network of actors having a secure access to the project. He has to control the information generated by actors before its publication: its access can be managed by pulled or pushed mechanisms.

3. Experimentation of collaborative solutions and results

3.1 A PLM system configuration for innovation

Product Life Management (PLM) systems co-ordinate actors’ activities by managing structured information i.e. documents. The evolution of a document is managed through a predefined life cycle and associated workflows [CIMdata 2001], [Nowak 2003], [Liu and Xu 2001]. More recently PLM systems integrate Web-based technologies and propose collaborative functions such as forums, agendas or office documents viewers. We study how a PLM system [Miller 2000] can be configured to allow actors’ collaboration during these early design phases according to the initial specifications.
We realise an experiment based on Windchill Project Link system (PTC) and propose a configuration that allows to manage the six classes identified in figure 1. We represent “concepts” by “folders” in Windchill. A “criteria” is used to generate an evaluation: it is represented by a “document type”. For each “concept/folder” an instance of a “document type” is generated as an “evaluation”. This configuration allows actors to formalise proposals and related evaluations.
Discussions can be traced using the “discussion forum” function of the PLM system: “questions”/ answers” and “warnings” can be associated to the whole project or to a specific document representing an evaluation. Finally “links” can be explicitly generated between two documents.
A PLM system allows the material expert controlling the information evolution at the document level. On one hand, each “document/evaluation” is associated to a specific life cycle and workflow. The life cycle has only three states: “in work”, “intermediate” and “validated”. The workflow is composed of three activities. First one allows a designer to submit his “evaluation” document to the material expert. The second one is a validation activity, if validated the document becomes visible to all actors, otherwise a modification activity is required and the process restarts from the beginning. On the other hand information generated through a forum or a link cannot be controlled by the material expert.
Figure 2 synthetises on its left part the structure of “folders” and “documents” for an innovative project and on its right part the detail of the evolution of an “evaluation” document.

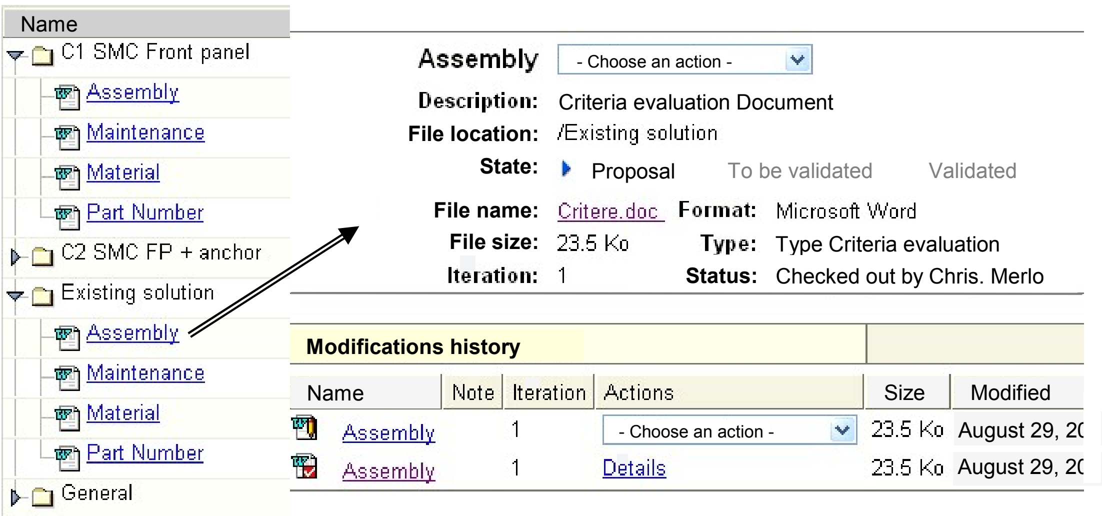

Figure 2. Structuration of «Concepts» folders and «Criteria evaluation» documents

Finally the material expert has the role of defining who is involved in his project. Actors can subscribe to specific events. For example they receive an email notification when an "evaluation" document reaches the "validated" state, or when a new answer is generated in a given forum.

This configuration answers to the collaboration needs when an innovation has to be promoted and introduced in the early design phases. Nevertheless to be evaluated in a real situation this solution requires that the company has implemented a PLM system. So we study also the implementation of a specific tool independent from an existing commercial system.

3.2 A specific collaborative tool: ID²

We develop a specific collaborative tool named ID² [Legardeur et al. 2001]. It proposes semi-formal information structuring in order to promote interactions between actors during the early phases of design projects. The heart of a project on ID² revolves around the Concepts Criteria Table (CCT), see figure 3.

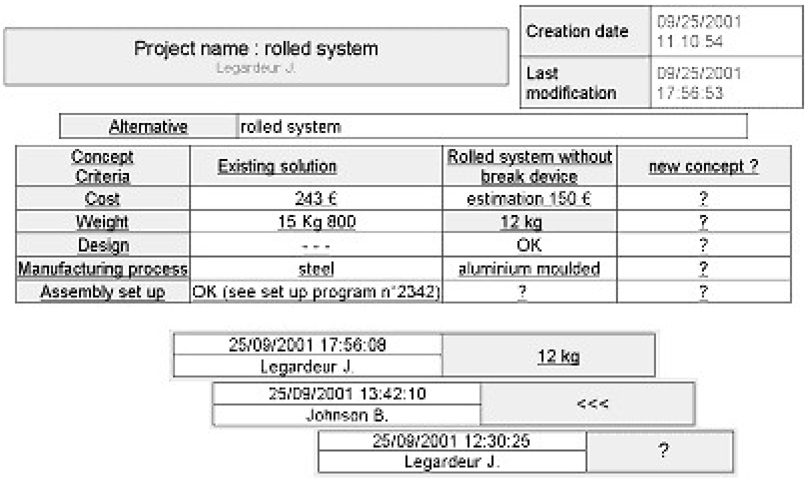

Figure 3. Concept and Criteria Table of ID²

The material expert acts as a project leader and defines its network of actors. ID² stores, classifies and shares the information exchanged through the CCT table. This table synthesises on a single screen all the information concerning the project: concepts, list of criteria and related evaluations. Criterias are progressively defined and proposed by actors from the network according to the proposed concepts. The existing solution, in the first column, is compared with the innovative proposals, in the following columns, against a number of evolving design criteria (rows). Interactions between actors are improved by the following functions:

- the material expert proposes concepts and criteria and validates information sent by actors,
- actors can propose new concepts or new criteria, but can also associate annotations (figure 4) to each evaluation ("questions" and answers, "warnings", or "links" of dependencies between two evaluations).

The idea is to provide a shared support tool enabling each actor to specify and explain his/her assessment criteria for the solutions.

ID² has been developed and tested with material experts and design engineers. As it is a specific development it responds to collaboration needs of the actors. Compared to a generic system such as a PDM system, it improves collaboration in several aspects. The main one is the introduction of the CCT table concept which synthethises on a single screen the relevant information for promoting a new solution. Another important aspect is related to the capitalisation and reuse of information to assist new projects. A specific procedure has been developed to capitalise a project, based on the identification of summaries and keywords. Then specific requests have been established to retrieve information and to explore stored projects.

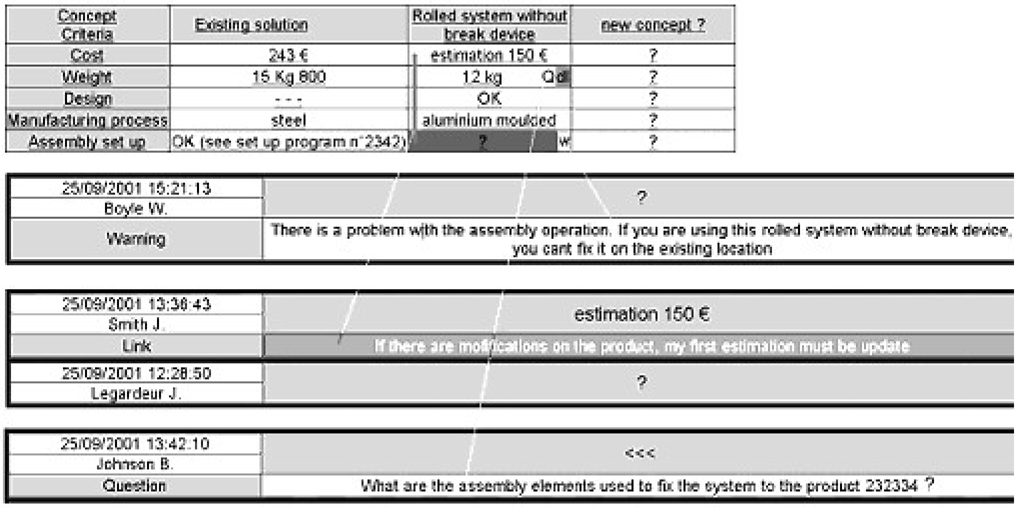

Figure 4. Annotations in ID²

We now discuss in the following section about the relevance of such collaborative tools to help actors to promote innovation in early design phases.

4. Synthesis

Through the Renault VI case study we have been able to experiment two different environments to support actors' collaboration. The main objective of these tools is to help actors to structure, to capture and to share information which is generally informal in early design phases. The ID^2 environment is still tested in different industrials and academics projects. However, we can compare the two tools propositions.

First the PDM configuration allows to structure information through a tree of folders and documents. This partially answers to the initial need of structuring and capturing the information. Nevertheless this implies also that actors don't see the evaluations: they need to open each document before. In order to facilitate their own evaluation and decisions and their motivation for collaboration they must have a synthetic view of the solutions and above all of their evaluation as it exists in ID^2 environment with the CCT. So PDM configuration appears limited on these aspects as ID^2 proposes a more detailed structuration of information.

Second the proposed PDM configuration requires that the material expert verifies that a new solution is correctly generated with all the necessary evaluation document. If a new criteria is defined he must add the corresponding evaluation document to all existing solutions. Within ID^2 the CCT allows an automatic generation of evaluation fields when a new solution or a new criteria is added.

We have restricted our experiment to the standard configuration of a PDM tool and this shows that PDM systems must evolve [Weber et al. 2002]. To improve this solution, we must consider the development of specific objects and the modification of its database structure.

On the contrary, the PDM collaborative functions such as forums, subscriptions and notifications have a great interest in our case study in the way that they facilitate actors interactions and information exhanges, pulled or pushed. As they exist in others PDM, we don't need to develop them again as we did it in ID^2. Nevertheless, these functions don't exist yet in all PDM systems even if we can consider it will be the case in a short term with the general implementation of Internet-based technologies.

5. Conclusion

In this paper we focus on the informal information management in the context of the introduction of product/process innovation for product design. In the early design phases, this introduction is not a traditionnal project but it is rather managed by an interface actor as a real project involving informal processes and specific actors strategies. We study this situation within R&D and design departments of an industrial partner and we define the corresponding collaborative processes. Then we characterise the required specifications for the definition of a collaborative environment which supports these innovative projects where information is not very well structured.

We propose the configuration of a PDM system by using its standard objects and functions. We demonstrate that it can answers partially to the specifications by realising compromise solutions based on a document structure. The use of the collaborative functions of the choosen PDM system are relatively appropriate with the collaborative aspects.

To conclude we think that our works highlight two kinds of result. On one hand our work shows that the developed ID^2 environment is more relevant than the PDM solution. If a PDM system can be used for the structuration and the capture of informal information, the granularity of managed information is not detailed enough as in a specific tool such as ID^2. We consider that the development of specific tools in adequation with the context of a company is still for the moment a good answer to facilitate innovation environments, informal exchanges and semi-structured information sharing.

On the other hand the implementation, the test and the integration of specific tools in a company generate at least so many problems as a PDM system. 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 and so on. Their implementation is made in a research context and the industrialisation and maintenance aspects are not taken into account. In that way the appropriation of the software by the users can be disturbed by the resolution of technical problem during the first experiments. Moreover the integration of such a tool must be linked to the existing systems in a company in order to propose an integrated environment which proposes homogeneous functions for collaboration actors and that guarantees the uniqueness of an information.

So in future work our objective is to study the integration of a specific tool such as ID^2 into a PDM system. By this way we expect to answer to collaboration needs for informal exchanges in innovation processes and on the same time to benefit from an integrated environment already present in the company.

References

Baumberger, C., Pulm, U., Lindemann, U., "Coordination and controlling of distributed product development processes",Proceedings ICED 2003, Stockholm, Sweden, 2003.

Boujut J.F, Tiger H, "A socio-technical research method for analyzing and instrumenting the design activity", Journal of Design Research, Vol. 2, Issue 2, 2002.

CIMdata, "collaborative Product Definition management (cPDM): An Overview", CIMdata Inc, Ann Arbor, http://www.cimdata.com/cPDm_request.htm, August 2001.

Finger, S., Konda, S., Subrahmanian, E., "Concurrent design happens at the interfaces", Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 9, 1995, 89-99.

Legardeur, J., Boujut, J.F., Tiger, H., "An interface tool for driving innovation during preparatory phases: Application in the design of composite parts", Proceedings ICED 2001, Glasgow UK, 2001.

Liu, D. T., Xu, X. W., "A review of web-based product data management systems", Computers in Industry, Vol. 44, 2001, p. 251-262.

Lowe, A., McMahon, C.A., Culley, S.J., "Comparison of alternative approaches for the automated organisation of design information", Proceedings ICED 2003, Stockholm, Sweden, 2003.

Miller, E., "Extending cPDM to Field Support ?", Computer-Aided Engineering Magazine, september 2000.

Nowak, P., Merlo, C., Eynard, B., Gallet, T., "From design process specification towards PDM workflow configuration",Proceedings ICED 2003, Stockholm, Sweden, 2003.

Weber, C., Werner, H., Deubel, T., "A Different View on PDM and its Future Potentials", Proceedings of the 7th International Design Conference DESIGN 2002, Dubrovnik, Croatia, 2002, p. 101-112.

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