Supporting collaboration in product design through PLM system customization

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Abstract: This paper deals with the proposal of a framework for coordinating design process through a PLM (Product Lifecycle Management) system. Design coordination implies that project managers are able to structure their project, assign resources and define the schedule of the resulting tasks with specific objectives and performance criteria. In Small and Medium Enterprises (SMEs) the design process is generally described at a macro-level which does not fully correspond to the complexity of the real process. To improve design coordination in SMEs a method for analyzing informal collaborative practices is introduced in order to help modeling detailed but flexible design processes. Then these processes are implemented by using PLM technologies: multi-level workflows are implemented to control document workflows through synchronization tasks.

Keywords: Design coordination, design process management, PLM systems, workflows, collaboration

1 Introduction

Design coordination implies scheduling / planning tasks and resources management [1]. In main companies the product development process is formalised at a high level and project managers have to respect the general identified phases and milestones. They have autonomy to structure projects and tasks but respecting this general framework. In such a context, coordination of the information flows within design teams is generally managed through PLM basic processes centred on documents life cycle.

In SMEs, design process is also structured and especially when the company is involved in a quality management certification. But most of the time companies undergo external risks and collaboration between designers has a strong influence on the process [2]. Flexibility is the main characteristic of design process in SMEs even if sometimes this situation leads to time consuming and a lack of coordination. In this context the formalization of information flows can lead to rigid processes that can disturb the operations of the company. When implementing a PLM system in an SME, we face two antagonistic problems: first to improve the level of formalization of information flows and second to keep a certain level of flexibility [3].

Our aim is to propose an approach that integrates these two problems in order to define flexible workflows based on the analysis of the collaboration among designers. In section 2 we focus on design coordination and PLM systems and we introduce the case study that will be developed all along the paper. Section 3 introduces a new approach based on collaboration analysis to increase the level of formalization of design processes. In section 4 we study the impact of this work on the implementation of PLM workflows dedicated to document management as well as design project coordination.

2 Design coordination and PLM systems in a SME

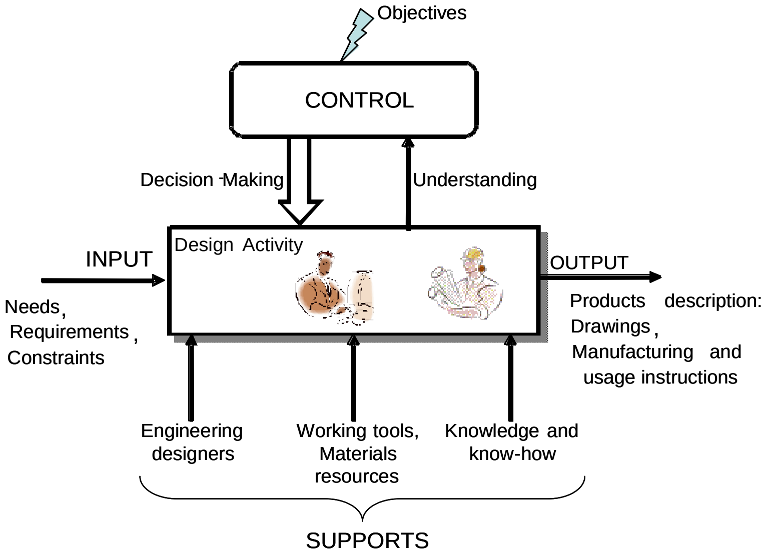
2.1 Design coordination

Today design projects depend on the ability to coordinate and to control the collaboration between the numerous actors participating in such projects: e.g. designers, experts from different disciplines and with different experiences, or external partners. Coordination and control of engineering design are part of a global approach for the development of new products which implies the need to identify the different situations occurring during the design process and the adequate resources to satisfy design objectives. In design project management, the control of the progress of design process can be defined as the understanding of existing design situations (in the real world) in order to evaluate them and take decisions that will modify and improve the future process, according to design objectives given by customer specifications or issued from the company strategy. The control problem here is a problem of decision-making to support designers in their activities [4] in order for them to achieve an objective in a specific context (figure 1).

Design activity has “input” and “output” information. Actors use the “input” in order to produce the “output”, to achieve their activity and they have “supports” namely: human and material resources and knowledge to help them in their work. For decision-making, project managers need to identify effective action levers which will influence collaboration thus increasing design performance.

In an SME design projects are generally different and require a specific study for each customer’s specifications. Most of the time, the small structure of the SME does not ensure project management in a routine way and leads to combine various responsibilities. Indeed there are not enough actors to fulfil each design role, so most of the actors have various design roles in a project. Consequently the role of informal relationships is very important in the SMEs in order that each design stakeholder may help each other without rigid formalities. Thus, the combination of various responsibilities and the informal relationships lead to a high level of workload because informal tasks are added to the official ones. Accordingly SMEs have to manage deadlines by setting an order of priorities on design tasks according to the objectives.

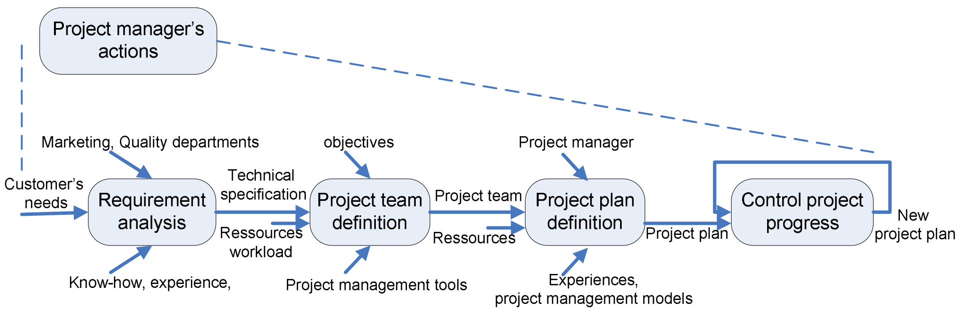
Figure 1 Coordination of design activities



Another point specific to SMEs is their project structures with a rigid formalization of their processes at a macro level and a very flexible non-formalization of the detailed processes which allows informal relationships into the project.

In this context, the project manager coordinates (figure 2) by analyzing the requirements from the customer, after which he defines the project team with its internal organisation [5]. He then defines the sub-phase of the project plan and activities in each sub-phase, next he defines a plan to control the project progress and finally he applies this control plan. Periodically he controls project progress and makes the adequate modifications according to the results and the design objectives.

Figure 2 Synthesis of the project manager's actions.



2.2 PLM systems and coordination

PLM (Product Lifecycle Management) systems are deployed within companies to support product data structuring and management throughout the product development process.

They manage information through document management and especially product data evolution using predefined workflows [6]. Actual PLM systems integrate Internet-based technologies and offer groupware-like functionalities [7, 8] for collaboration among actors. Several PLM systems have recently introduced project management functionalities [9]. Most of the time these functionalities allow the formalization of tasks and milestones schedule. Nevertheless this project implementation reveals strong limitations [10] if correlated with design coordination. On the one hand the management of deadlines and the modifications of tasks sequences can be made dynamically.

On the other hand, it is not possible to ‘reuse’ predefined tasks sequences or to ‘redo’ specific ones as compared to workflow capabilities. Main limitation concerns the impossibility to drive documents life cycles from the tasks schedule. If a deliverable can be associated to a milestone, this only means that the end of the deliverable lifecycle must occur when the milestone is achieved, but no synchronization is possible before the lifecycle end. Consequently in the SME context we consider that there is no integration between macro-level project management and the micro-level document oriented process management, each level being managed through different technologies implementation. Nevertheless some PLM systems are able to manage workflow without associating them to documents: the proposed framework will be based on this assertion.

These considerations highlight the necessary flexibility of a design process in an SME. If the process is predefined at a global level as it is required by a PLM system, this is rather incompatible with actors from all departments working daily in a context of “mutual fit”. The processes of cooperation are quite unstructured and the confrontation of the various project teams’ points of view leads to informal and unofficial information exchanges [2]. When establishing a schedule in a SME it is an important issue to identify what must be really controlled and so predefined through a workflow, and what must be encouraged and not detailed. The management of the product development processes requires greater flexibility in the activities [11]. The coordination through PLM systems must be studied in order to integrate document workflows and to introduce flexibility into such workflows [12] for global project coordination.

2.3 Presentation of the case study

The industrial case study has been achieved in an SME which, some years ago, developed a new means of manufacturing structures using honeycomb sub-assemblies. This innovation confers lightness and significant vibration absorption on products whilst maintaining similar rigidity to steel. The company has captured several markets with products manufactured using its technology and consequently the number of employees grew from 4 to 40 over 10 years. Over this period the organisational structure and internal processes have not been formally revised. The objective of our study was to help the company to reorganise and to introduce the role of “design project manager” in order to manage further growth. In this context, problems of organisation, project management and relationships with suppliers, customers, and subcontractors come into play. We have first studied and analyzed the company’s design and industrialisation department. Then we have formalised: a new organisational structure; the processes of development of new products and the management of technical information and of product data.

After this first phase we have focused our work on the study of collaboration and relationships between actors and on the design project coordination [13, 14]. In the next section we introduce this approach and give some results of its implementation.

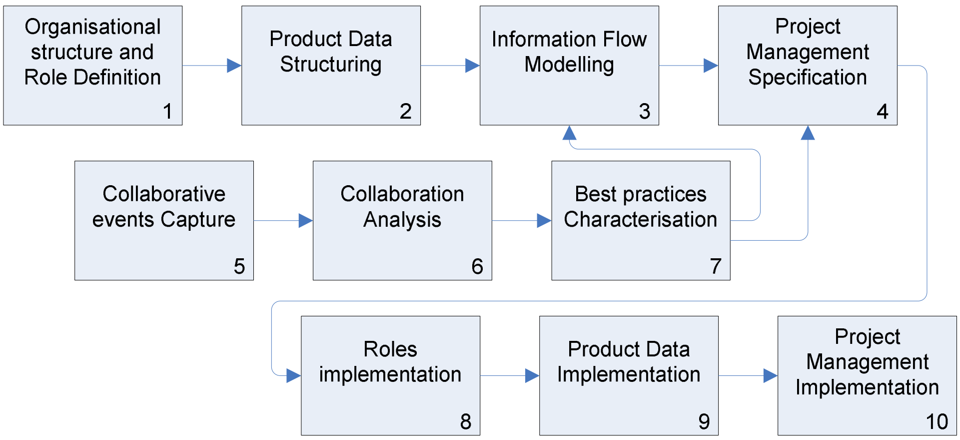
3 From collaboration analysis to design processes characterization

3.1 Collaboration analyses: a method to improve design processes definition

In a previous work of the authors [15] a model and a software tool have been presented to track the collaboration between designers. The model deals with the identification of the main relevant elements for the characterization of the collaborative situations in design. Collaborative situations are defined from a coordination point of view, with scheduling, planning, and the definition of milestones and activities. Alternatively, they are also defined from a human relationships point of view with the persons involved in the collaborative event, their skills, their motivation, and their form of communication. Both points of view are considered to characterize the factors of tracked collaborative events.

To support the traceability of the events, their characterization and the context of the project, we have implemented a software tool named CoCa (an acronym for Collaboration Capture) in order to implement the proposed model and to help managers to analyze collaborative situations occurring in projects. The following method has been proposed to integrate the analysis of collaborative situations into a PDM implementation method, as shown in figure 3. Several steps belong to a generic PDM implementation method, as proposed in [14]: steps from 1 to 4 correspond to a specification phase then steps from 8 to 10 to the configuration and implementation phase.

Figure 3. Method for improving PDM implementation through collaboration analysis



To take into account collaboration analysis, three further steps are now introduced:

- Step 4: Tracking data about collaborative events and their evaluation with CoCa tool.
- Step 5: Analyzing captured data to identify problems or possible improvements, to establish links between events and to define best practices through good tasks' sequences.
- Step 6: Integrating existing process formalization with the identified task sequences.

Step 4 is managed by analysts that are involved in design projects in order to store each collaborative event. In step 5 they have to establish correlations between events in order to identify problems or best practices. One of the expected result is the identification of task sequences corresponding to the resolution of a problem linked to an inadequate process for a given design situation, or to the formalization of an adequate process for another given design situation. That means that in step 6 'good design practices' are formalized for specific design situations. As the 'good design processes' are defined through a deep study of real events occurring during a project, their level of granularity is more accurate than generic processes defined after the interviews of some experts and managers. By this way the added-value of the analyst is then to integrate the adequate 'good design processes' into the generic ones as templates [16]. To do so, he may define nodes of flexibility: at these nodes the future context of the project will allow the user choosing between several possible sequences.

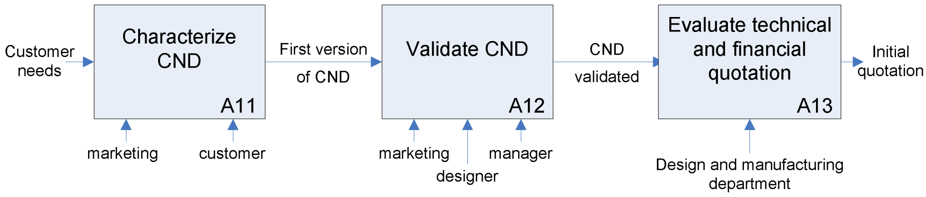
As a consequence, this integrated method allows the establishment of links between the analyses of collaborative practices and the formalization of more complex and flexible workflows. Next section will illustrate this method.

3.2 First experimentation

After four months of tracking projects in our industrial partner, four different projects have been deeply analyzed and more than one hundred collaborative events have been stored. Following example illustrates the consequences of such analyses on the project management: the introduction of flexibility and detailed implementation of design processes. The example is based on the CND (Customer's Need Definition) process which corresponds to the initial financial quotation phase of the design for the customer.

Initially, the CND document was managed by the marketing person who builds the document in collaboration with the customer. Indeed this step defines the specification of the product on the basis of the need expressed by the customer.

Figure 4 First steps of the design process



The first activities of this phase were (figure 4):

- Definition of the CND document by marketing person with the customer (task A11).
- Validation of the document (task A12).
- Notification that the document is complete (between A12 and A13) to the technical department and that a designer has to make the quotation (future tasks A13).

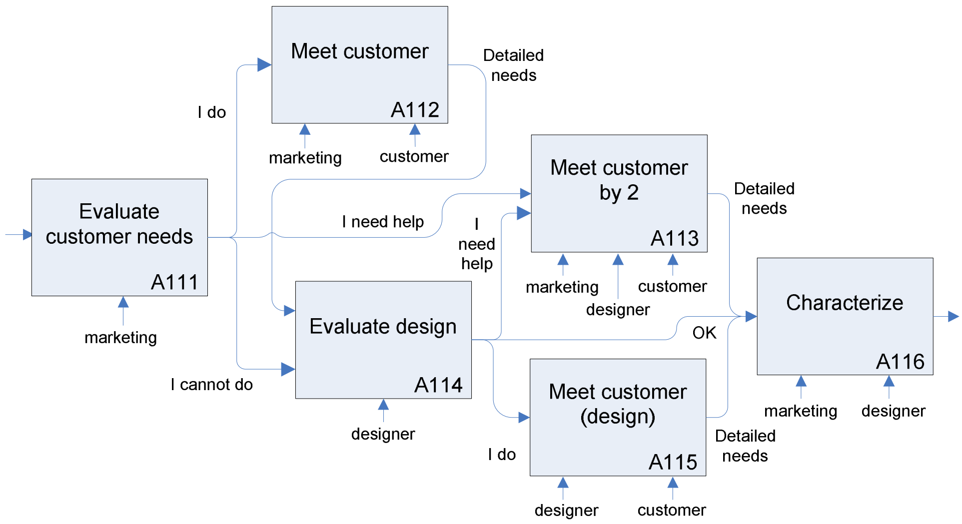
The analysis of this initial collaborative situation through several projects allows identifying that CND process description incorporates neither details on the way to achieve the tasks, nor flexibility. Moreover the marketing person does not always have the necessary technical skills for all customers, and furthermore he does not have enough time to carry out all the CND processes. So problem of customer data management appears between the marketing and technical departments.

With the analysis of the collaboration with the CoCa tool, the analyst can define guidelines and more detailed processes. In this way, the CND process is updated with an increased level of granularity based on the guidelines from the collaboration analysis.

Consequently a new process is proposed: in figure 5 is detailed previous task A11. The marketing person first evaluates the needs of the customer (task A111), then he can:

- reject directly the customer request, if the customer needs are not appropriated for the company (not formalized),
- make a visit to the customer: alone (task A112) before sending the detailed needs to the designer (task A114) or with a designer (task A113),
- or directly send the needs to the designer if they are enough detailed (task A114).

Figure 5 Detailed but flexible process for A11 task



Afterwards when the designer evaluates design (A114), he can meet the customer alone (A115) or with the marketing person (A113), or directly characterize the CND document (A116). At each task marketing person or designer have the possibility to end the process. As a conclusion the project manager has the possibility to automate the design process by implementing a PLM system with this process. The first node of flexibility is the task A11 because the detailed sub-level may not be scheduled for a specific reason. Next nodes of flexibility are associated to tasks A111 and A114 as choices exist for the owner of the task. Next section develops the implementation of such process into a PLM system.

4 A PLM framework for the coordination of design processes

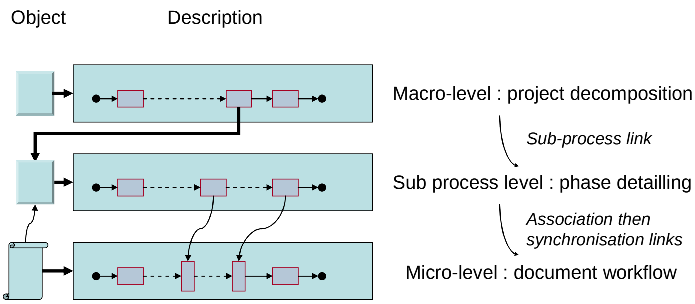
4.1 A framework for multi-level workflow implementation

In the SME context, design process is generally formalized at a macro-level: the process is decomposed into several phases, and main tasks are defined in each phases, as shown in figure 4. As a consequence of the results obtained with the collaboration analysis method, we are able to specify more accurately at least one sub-level: some tasks of macro-level are decomposed into detailed tasks sequences by the identification of collaborative practices that are linked through flexible nodes.

Our first proposal is to characterize the project phases by using a generic workflow: each phase and each milestone of the project are respectively represented by a sub-process and a task. Then each sub-process / phase is defined as a traditional workflow, without document association. Each task of the sub-process / phase must specify to the owner what the documents to be created or modified are. A second level of sub-processes is not possible to control document workflow because document workflows are not “contained” inside a single task of the sub-process / phase, but can be achieved after several tasks of a sub-process / phase, and sometimes after several phases.

Finally at micro-level very basic processes that manage document lifecycles are identified. In this case we need a certain level of correlation between the sub-process / phase workflow and the document in order to synchronize the progress of both processes with the project schedule. This link allows getting information from the document (states, owner …) during the progress of the sub-process workflow.

Figure 6 Multi-level workflow framework for design process management



Such document processes are not always necessary: in most SMEs they reduce the flexibility and they are not implemented. If this is the case, a minimal workflow is still necessary in order to establish the required link. The implementation of such links depends on the functionalities of each PLM system.

Figure 6 illustrates main concepts of the proposed framework for the implementation of the proposed workflows from the macro-level to the micro-level. Vertical boxes at micro-level show the possibility of getting document state from the sub-process level.

4.2 Second experimentation

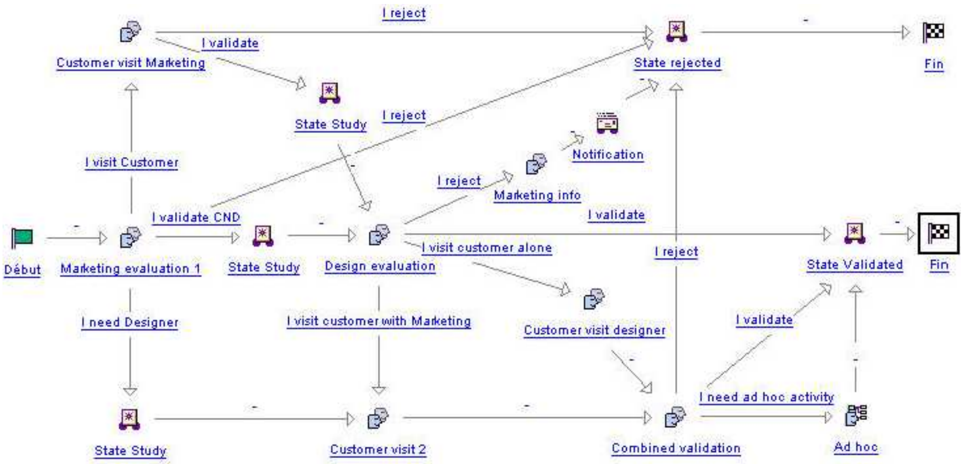
This experimentation is based on Windchill™ (PTC) PLM system. Actually macro-level and sub-process level have been implemented. These two levels can be implemented with traditional workflow configuration.

As an example figure 7 illustrates the workflow defined for managing the CND phase as explained in section 3.2:

- ‘State’ tasks define the state modification of the CND document.
- All possible ends of the process are also defined as well as the required notifications.

- 'Ad hoc' tasks correspond to the possibility given to a user to create dynamically new required tasks. This allows introducing more flexibility in the design process.

Figure 7 CND phase workflow



The last micro-level is still under development as it requires specific configuration. For example with Windchill the possible mechanisms of synchronization tasks require some Java development.

Such experiment demonstrates that it is possible to implement a framework for multi-level-workflow management. Nevertheless the technical aspects of its implementation depend strongly on the openness of the used PLM system and their possibilities of customization: can document-independent workflow be managed within this PLM system? then can independent workflows be synchronized through their tasks? When validated these requirements imply that the coordination of design projects is possible using this framework. Nevertheless some considerations still remain. The main concerns the acceptability of such multi-level management into SMEs: our industrial partner has a size that requires more formalization while maintaining high level of flexibility. As the framework is not achieved we still do not know if the flexibility and workflows that we propose correspond to this situation with adjustments or not, *a fortiori* for other SMEs.

5 Conclusion

In the worldwide competition among companies, the development of new products has become a challenge where innovation and coordination of design process are two main keys for success.

In SMEs design activity is not completely structured and controlled due to the high level of flexibility of processes. At the same time PLM systems help to rationalize basic design processes and are the main information systems managing the product life cycle in companies. In this paper we have focused on the proposal of a framework for design coordination implemented through a PLM system. First we have proposed an adapted method for implementing PLM systems in order to take into account both more detailed process definition and flexibility by using the analysis of collaborative practices. Second this framework is based on the use of workflow technologies in order to elaborate the structure and the schedule of the project phases and tasks through different and synchronized levels of granularity. First results are enough significant to justify the interest of this framework and future work for implementing all the functionalities of this framework and its experiment in an SME.

References

1 Coates, G., Whitfield, R.I., Duffy A.H.B., Hills B. (2000) `Coordination approaches and systems. Part II. An operational perspective'. *Research in Engineering Design*. No. 12, pp.73-89.

2 Baumberger, C., Pulm, U., Lindemann, U. (2003) `Coordination and controlling of distributed product development processes', Procee*dings of the 13th International Conference on Engineering Design - ICED 2003*, Stockholm, Sweden.

3 Weber, C., Werner, H., Deubel, T. (2002) `A Different View on PDM and its Future Potentials', *7th International Design Conference DESIGN 2002*, Dubrovnik, pp.101-112.

4 Girard, Ph., Doumeingts, G. (2004) `Modelling of the engineering design system to improve performance', *Computers & Industrial Engineering,* Vol46, No. 1, pp.43-67.

Merlo, C., Pol, G., Legardeur, J., Jared, G. (2006) 'A tool for analysing collaborative practices in project design', *12th IFAC Symposium on Information Control Problems in Manufacturing INCOM'2006,* Saint-Etienne, France.

5 Mintzberg, H., (1990) `Le management. Voyage au centre des organisations', Edi*tions d'Organisation*, Paris.

6 Liu, D.T., Xu, X.W. (2001) `A review of web-based product data management systems', *Computers in Industry,* Vol. 44, pp.251-262.

7 Johansen, R. (1988) `Groupware: computer support for business teams', *The Free Press*.

8 Eynard, B., Merlo, C., Carratt, B. (2002) `Aeronautics Product Development and Certification Workflow based on Process Modelling', *8th International Conference on Concurrent Enterprising (ICE'2002)*, Rome, Italy.

9 Saaksvuori, A., Immoen, A. (2004) `Product Lifecycle Management', *Springer-Verlag*, Berlin.

10 Pol, G., Merlo, C., Jared, G., Legardeur, J. (2005) `From PDM systems to integrated project management systems: a case study', *International conference on Product Lifecycle Management, PLM'05*, Lyon, France.

11 Weber, C., Werner, H., Deubel, T. (2002) `A Different View on PDM and its Future Potentials', *7th International Design Conference DESIGN 2002*, Dubrovnik, pp.101-112.

12 Saikali, K. (2001) `Flexibilité des workflows par l'approche objet: 2Flow: un framework pour workflows flexibles', PhD Thesis of Ecole Centrale de Lyon.

13 Duffy, A.H.B., Andreasen M.M., O'Donnell, F.J., Girod, M. (1997) `Design Coordination'. *Proceedings of ICED 97*, Tampere, Finland.

14 Pol, G., Jared, G., Merlo, C., Legardeur, J. (2005) `Prerequisites for the implementation of a product data and process management tool in SME'. *15th International Conference on Engineering Design, ICED05*, Melbourne, Australia.

15 Merlo, C., Pol, G., Legardeur, J., Jared, G. (2006) `A tool for analysing collaborative practices in design projects'. *12th IFAC Symposium on Information Control Problems in Manufacturing, INCOM'06*, Saint-Etienne, France.

16 Gzara Yesilbas, L. (2005) `Flexibility in PLM deployment Processes: Focus on Workflow and Services', *International conference on Product Lifecycle Management, PLM'05*, Lyon, France.