Journal of Universal Computer Science, vol. 17, no. 2 (2011), 224-242
submitted: 17/9/09, accepted: 7/12/10, appeared: 28/1/11

Managing Mechanisms for Collaborative New-Product Development in the Ceramic Tile Design Chain

María-Jesús Agost
(Dept. of Mechanical Engineering and Construction. Universitat Jaume I, Castellon, Spain
magost@emc.uji.es)

Pedro Company
(Dept. of Mechanical Engineering and Construction. Universitat Jaume I, Castellon, Spain
pcompany@emc.uji.es)

Fernando Romero
(Dept. of Industrial Systems Engineering and Design. Universitat Jaume I, Castellon, Spain
fromero@esid.uji.es)

Abstract: This paper focuses on improving the management of New-Product Development (NPD) processes within the particular context of a cluster of enterprises that cooperate through a network of intra- and inter-firm relations. Ceramic tile design chains have certain singularities that condition the NPD process, such as the lack of a strong hierarchy, fashion pressure or the existence of different origins for NPD projects. We have studied these particular circumstances in order to tailor Product Life-cycle Management (PLM) tools and some other management mechanisms to fit suitable sectoral reference models. Special emphasis will be placed on PLM templates for structuring and standardizing projects, and also on the roles involved in the process.

Keywords: Collaborative product development; Ceramic tile products; Design chain
Categories: H.4.m.

1 Introduction

The design of the New-Product Development (NPD) process, and the organization and the infrastructure that support it, are critical elements to sustain the competitiveness of industries in which product innovation is the key strategy. This is the case for most of the ceramic tile manufacturers in the Castellón (Spain) cluster. The design and development of new ceramic tile products involve many actors (companies and other organizations or people belonging to the ceramic tile cluster), who play different roles within the process. The relationships maintained among them allow collaborative networks to be constituted.

The CE-TILE project [Vila, 05], [Romero, 08] was launched with the aim of improving the efficiency of these networks and solving the work and information management problems related to the NPD process in what we call 'Ceramic Design Chains'. This was to be achieved by taking advantage of the benefits of the services provided by the Internet and web technologies. After a preliminary analysis of the NPD processes (for ceramic tile products), a conceptual framework focused on collaboration was proposed. Moreover, specific reference activity models were established and an organization and Product Life-cycle Management (PLM) support infrastructure were developed. Finally, a pilot project, which reproduced a real ceramic development project, was conducted [Romero, 08]. The empirical study was conducted in enterprises belonging to the ceramic tile industry in the province of Castellón (Spain) that play important roles in the Ceramic Design Chain, such as ceramic tile manufacturers, colour and glaze suppliers, mould suppliers or manufacturers of special trim pieces. It was focused on determining the R&D strategies adopted by the enterprises in the Ceramic Design Chain, their actors and activities, the mechanisms that existed for interaction and the current management models. The study led us to a number of conclusions.

First, the profile of the Castellón ceramic tile cluster may be described from an R&D point of view as a cluster which, as has already been described for other sectors, does ‘conform to the *informal sharing of technology models* in that known product technologies were generally shared between producers who continued to jointly manufacture finished products through a vertically disintegrated system’ [Oakey, 07]. This is a usual profile in low-technology sectors, where inter-firm relations are non-hierarchical and there is a lack of both the management leadership and the rigid protocols imposed on highly structured clusters by OEMs (Original Equipment Manufacturers). However, there can also be large differences in profiles from one non-hierarchical cluster of SMEs to another. The tile industry profile is clearly different from the profiles of other clusters of SMEs, like small high-technology firms.

Recent studies [Oakey, 07] demonstrate that direct cooperation with adjacent firms in the same sector is not as obviously advantageous as it was said to be in the past for small high-technology firms. In contrast, in the ceramic tile cluster (which can be considered a low-technology one) R&D management is not affected by a rigorous internal control of the invention process. Therefore, two kinds of cooperation can appear. The first type occurs between ceramic manufacturers with different productions or markets. The second kind takes place between ceramic manufacturers and equipment suppliers (primarily moulds) and colour and glaze suppliers, which provide them with knowledge and expert advisory services.

We will argue that the absence of leadership may be compensated through the development of a VO (virtual organization) breeding environment (that is to say, a ceramic collaborative cluster). This will consist of a wide range of dynamic companies in the sector, with: a) reference models for the processes involved in creating project/ programme[1] -based VO’s [Murman, 02] and for the planning and fulfilment of the work of these dynamic VOs [Camarinha 05, 08, 09] and b) common PLM tools capable of supporting the technical cooperation and the management of the projects/programmes. They should also be easily adaptable to the particular circumstances of the VOs in this kind of cluster.

---

[1] We shall use the term ‘programme’ to define a set of projects developed with the aim of covering a market opportunity and which gives rise to a business proposal to be presented at a particular sectoral trade fair.

Second, it has been reported that teams developing new products under rapidly changing technological or market conditions deserve special attention [Akgün, 07]. And we shall see that fast market changes clearly dominate NPD in the ceramic tile industry. We hypothesized that an important feature to obtain efficient NPD process models for ceramic tile clusters is to encourage frequent cross-functional interactions based on the creation of multidisciplinary and inter-firm teams and on establishing organizational structures and appropriate roles for managing the different types of projects/programmes that may take place in these environments.

Based on these findings and these hypotheses, and after an overview about the management of NPD projects, the Universitat Jaume I research group considered the need to design a generic NPD process model for companies belonging to industrial sectors based on trends and fashions. This model, called the 'Enterprise Model for the Implementation of Collaborative Design Systems' (EMICS), takes into account the creation of VOs and the planning and execution of NPD projects/programmes. From this generic model, another more specific one was developed (Ceramic Design Activity Model – CEDAM) [Romero, 08]. In addition, a collaborative design platform and different mechanisms were also prepared. The research group considered mechanisms as templates for both the project structure and the information/documentation structure or for setting permissions and authorizations for the project roles, in order to thus facilitate cooperation and management in the project. Furthermore, it should be noted that the Universitat Jaume I research group acted as an Application Service Provider (ASP).

For the development of the pilot experience, the creation of a dynamic VO was simulated, the aim of the VO being the design and development of a series of ceramic products. The project was led by a ceramic tile manufacturer and a supplier of colours and glazes. A supplier of moulds and a manufacturer of tile complements also participated. Moreover, a consulting firm specialized in enterprise information systems acted as consultants in the project. The main aim was for the model and the technological platform to act as a solid base for the development of a VO breeding environment for ceramic design projects. Although the pilot experience was limited to a single development project, actually a set of projects were developed simultaneously to be presented in each fair of the ceramic industry. Relationships within and among networked project teams and integration teams (in a programme of projects) should therefore be coordinated.

Our analysis of the design processes currently used in the ceramic sector and the subsequent pilot experience in the CE-TILE project revealed the existence of a number of elements that should be considered in the management of the projects, both at an internal level and also in the collaboration between firms in the ceramic design chain. The lack of a strong hierarchy and fashion pressure, which demands dramatically shortened development times, combined with the existence of different actors and different kinds of relationships among them (depending on the diverse origins and objectives of the NPD projects), were considered to be the main singularities to be solved during the design and management of a project/ programme-based VO.

Taking those two singularities into account, this paper delves into certain aspects related to the structural and functional dimensions [Camarinha, 07] that complete previous contributions described elsewhere [Romero, 08], [Vila, 05]. In the structural dimension: 1) it aims to identify all the participating actors as well as their inter-relationships, and 2) it describes and characterizes the roles that can be performed by the actors in the network. In the functional dimension, the work focuses on some procedures related to the project/programme planning, execution and control processes. It also focuses on information and communication management.

In the following section we outline the related work about collaborative NPD (and product life-cycle) management. Section 3 considers the main singularities and shortcomings of NPD in the tile industry. The main stakeholders in the ceramic tile design chain are also described. As a consequence of the messy relationships that happen in this collaborative network, a variety of stimulators and stimuli for the origin of designs can be identified. Section 4 proposes some mechanisms for improving collaboration and for overcoming the shortcomings that were previously identified. Special emphasis will be placed on PLM functionalities and templates, which make it possible to structure and standardize the development projects, as well as to manage the relationships and communications between the different roles involved in the projects. The paper ends with the main conclusions.

2 Related work

NPD processes have been extensively studied in companies from different sectors and with different competitive strategies. Harmancioglu et al. [Harmancioglu, 07] conducted a collective case study in three strategic business units that operate in the building materials industry, i.e. in low-technology markets. Some of the conclusions they obtained are therefore relevant to our study. For instance, enterprises working for low-technology markets face the challenge of balancing formality and flexibility, and their processes are tailored to the immediate requirements of their environments. Based on their observations, the authors suggest a conceptual framework and a set of formal propositions on how to design and implement a brand new NPD process for increasing innovation productivity that suits their NPD environment. In this framework, they distinguish five elements (Senior management involvement, Use of formal stage-gate processes, Business case content, Customer input and feedback, and Cross-functional integration) that will be combined depending on whether the aim is to promote efficiency or creativity in the NPD process. In the words of Harmancioglu et al. [Harmancioglu, 07], there is no ‘one-size-fits-all’ solution.

The authors indicate that the most innovative enterprise in the study takes a more formal and centralized approach in order to reduce uncertainty and to make strategic decisions, while also encouraging frequent cross-functional interactions and collaborations so as to minimize divergence and establish shared values. With regard to the customers’ relationship (a fundamental requirement in fashion-driven enterprises), Harmancioglu et al. show that in the most innovative enterprises ‘innovations provide value and new uses resulting from allocating additional effort to technical activities and less to customer interactions and market information gathering’. Another work that deals with cross-functional integration is one by Abecassis [Abecassis, 06], which offer the example of a buyer-driven commodity chain where fashion makes design a key dimension for the success of a product in the clothing industry. Abecassis [Abecassis, 06] demonstrates that the strategy of integrating design and retail in the clothing industry results in improved product performance.

Collaboration is vital in our case, as we adopt a strategy based on innovation. In their realistic and myth-breaking work, McIvor et al. [McIvor, 06] argued that communication problems were identified during 'early supplier involvement' (ESI) in a series of case studies involving a number of multinational corporations. Typical issues included poor guidelines for supplier involvement, integration of suppliers into company systems that were not implemented correctly or standardization efforts hindered by outdated information. Swink et al. [Swink, 06] stressed the relevance of factors such as a collaborative work environment, design manufacturing integration or project activity overlap (concurrency) to distinguish between efficient and inefficient NPD projects.

Computer tools that facilitate collaborative NPD, such as PLM solutions, are also needed. A well-known fact is that tools that assist in 'high-level' cooperation tasks, like web-based engineering design tools, offer the opportunity to cut the cost of the product development process [Chang, 06]. However, adapting these tools to design chains is a complex issue, especially in inter-enterprise and collaborative design environments. The work by Aziz et al. [Aziz, 05] is one of the most straightforward and comprehensible reviews on collaborative product development aided by diverse computer tools. It includes a good diagnosis of the problems that are dealt with, namely the lack of support tools for SMEs and their specific requirements. We strongly agree that: a) only large enterprises have been the target of PLM vendors, b) configuration changes in global PLM or mapping business-to-business (B2B) links are difficult, long and costly processes, and c) some tools neglect the management of intellectual property in Virtual Enterprises. We also agree with Aziz el al. in that the use of current applications that make collaboration possible using B2B protocols is a problem, because dissimilar enterprises do not have unitary data models or workflows. Again, we agree with Aziz el al. in that moving from document-centric PLMs to knowledge-centric systems would be a bonus. However, we think that this step could be considered in the future, when Knowledge Management Systems in collaborative environments that are currently being developed in academic environments become commercial solutions.

Current academic approaches are supportive as they help to fix some problems and introduce algorithmic solutions in aspects that are important for heterogeneous scenarios, like the one considered here. For instance, Tomek realized that Collaborative Virtual Environments are a prerequisite for the information capturing part of a Knowledge Management System [Tomek, 01]. Later, Janev highlighted the subtle distinction between knowledge management solutions and information management solutions [Janev, 05]. Gutwin et al. [Gutwin, 08] have recently stated that much of the collaboration that occurs in a co-located work group is informal and opportunistic. Hence, further improvements in roles and collaboration management should be addressed. In this regard, the tools and approaches described by Geyer et al. [Geyer, 08] seem quite promising. In spite of all these academic achievements, and despite commercial applications still being high-priced and complex, their customization is nowadays easier than that of the previous PLM tools, and their cost may now be assumed by the OEM or shared among limited partners. Chang [Chang, 06] claims that web-based tools related to product development may be applied to foster companies' operational excellence. In our analysis we considered factors that Chang points to as being necessary for successful product development, such as communication, information sharing, collaboration, design verification and team management.

As a consequence of this review of the state of the art, the decision was made to use ASPs. The reasons for so doing were to avoid the high costs of B2B solutions while reducing the need for SMEs to acquire abilities to participate in dynamic VOs, and despite the problems inherent to the management of the intellectual property of the individual enterprises. It should be noted that the weaknesses of those SMEs can hardly be compensated by computer applications as most of them are still under development at the academic level. Fortunately, the new commercial web-based project management systems allow this option to be selected, although they require the participation of an external ASP.

3 Analysis of the ceramic design process

R&D management in general does not receive the attention it requires in all ceramic tile firms. Chiva and Alegre [Chiva, 04] found two approaches to product design management in the Spanish ceramic sector based on two design innovation strategies: 1) the approach followed by Design Innovators, and 2) the one followed by Design Followers. Such strategies have also been described in the literature as innovation-generating and innovation-adopting organizations [Damanpour, 06].

The situation is even worse in collaborative clusters. According to the studies conducted to date, relationships among the firms in the ceramic sector are largely centred on strategic and market aspects. For instance, Flor and Oltra [Flor, 05] identified the Spanish tile industry as being of low R&D intensity, where specialized technological change comes mainly from suppliers of machinery and raw materials. They claim that collaboration with these firms is a common characteristic in the ceramic tile sector and reflects a general pattern of behaviour in industries where R&D is poor. Yet, they also noted that investment in engineering design and pre-production has a positive effect on exports. Therefore, assigning resources to industrial design, production engineering and marketing helps to improve exports and, consequently, business results. In contrast, there are also claims that cooperation among firms does not improve export results. Hence, if contradiction of the foregoing statement is to be avoided, it can be deduced that either the pattern of collaboration is identical in the firms that were analysed (and so there is no difference between them) or not enough research has been carried out on the existence of different management models concerning cooperation with suppliers. We are more in favour of the latter alternative.

3.1 Information capture in the CE-TILE project

The information on interactions taking place among the different participants in the design chain throughout NPD projects (i.e. the strategy) was obtained as a side result from a series of interviews aimed at determining the processes that are present in the ceramic design chain. The interview process included firms that produce ceramic tiles, ceramic moulds, trim pieces and colourings, and is described in [Agost, 06a].

First, a spokesperson (the marketing or the graphic/ceramic design manager) was established for each ceramic tile enterprise. Then, organizational charts were studied to determine the departments involved in the design and development process. This allowed us to go into design activities and processes in depth. Interviews in supply companies were conducted with the people in charge of interactions with manufacturer enterprises in the design and development process. These interviews were aimed at identifying the exchange of information and existing collaborations.

The gathered information was formalized through an IDEF0 ‘as-is’ model representing activities as they were taking place. More specific interviews were also conducted to obtain information about the nature and content of information systems software (such as databases, ERP systems, etc.). The forms for managing information about activities and entities were adapted from the MOKA approach [Stokes, 2001]. Both forms eased the structured capture and recording of information during the interviews, while were also helpful in establishing the scope of the knowledge required.

A study of the main origins of designs (see section 3.2.), the factors that characterize the planning and execution of projects, and the elements used for communication (see section 3.3.) gave us some reasonable evidence of what can be construed as certain weaknesses and strengths in the interactions throughout the process of designing and developing ceramic products.

3.2 The stakeholders in the ceramic tile design chain and design origins

In our study we observed the presence of different actors (enterprises, departments, workers) and different kinds of relationships among them [Romero, 08]. We called these actors ‘stakeholders’, following the definition put forward by Claros Salinas et al. [Claros Salinas, 08], i.e. ‘a person who is involved in the design’. The following were considered to be the stakeholders in the ceramic design chain:

- Ceramic tile manufacturing industries, in which there are many functional departments involved in the design process, including marketing, commercial, graphic design, ceramic development, manufacture, logistics, etc. Some ceramic tile firms, however, do not have their own design and/or development departments.
- Firms that manufacture ceramic colourings and glazes; in recent years, in addition to supplying these components and providing technical assistance, these companies have also begun to offer new fully developed designs. By so doing they also provide innovations in new decorative and aesthetic effects.
- Design offices, which sell their own designs to ceramic tile manufacturers.
- Industries that produce special trim pieces and design and make complements for basic pieces, such as borders, skirting or steps.
- Firms that provide supplies and machinery, such as manufacturers of moulds. These also collaborate by providing technical advisory services and conducting studies to test relief patterns, etc.

Although there is no clearly defined vertical hierarchy, the tile manufacturer is usually the core of all cases of cooperation in the ceramic design chain. Therefore, a person who is to be responsible for relationships and communication with the suppliers and partner companies is determined. This person is often a member of the technical staff involved in product development and with extensive technological knowledge about the product. In the other companies, a person from the technical or commercial staff usually plays this role as a partner in the relationship with the tile manufacturer.

We also discovered that the general cycle of project development is determined and limited by the international trade fairs, where manufacturers introduce their new products. In the case of this sector, perhaps the most important fairs held throughout the year are Cersaie in Bologna, Cevisama in Valencia and Coverings in Florida. The pressing demands with regard to development times have led to a pronounced tendency to focus efforts annually on just one or two of these fairs at the most. Therefore, the different projects undertaken for a trade fair (i.e. the programme) will have to be managed globally.

As a positive aspect, the existence of certain processes of phase-approval has been identified, although in a very informal manner. For each project, approval is given (by marketing and commercial staff) if previously established requirements and deliverables are met. As the basic structure of the phases of all projects is the same, multi-project approval (at programme level) is favoured. This implicitly involves the management of times, workload, resources, costs, sales forecasts, risks, and so forth. Thus, the development process is actually funnel-shaped. Different projects are competing against each other in a programme, so that not all initial projects reach the end of the process. Some companies have the strength to incorporate the participation of customers (particularly, commercial dealers) in the design process, by conducting meetings on the completion of certain phases. The customers then show their priorities by selecting the models that come closest to their preferences. This information will be considered by marketing and commercial management for the selection of the products that are to go forward into the next phase of development. In any case, these approvals are not handled formally, but made in a poorly systematic manner, without establishing the roles, programming, aspects to be checked, decision methodology, and so forth.

It was also discovered that there could be different origins for an individual project (a request, an idea or an initial prototype). In what follows, the different origins of the designs in the ceramic design chain have been classified according to their stimulators (i.e. the different members who, at some particular time, can take the initiative of launching a new design) and the types of stimuli (i.e. the reasons that can set off a new design process).

Ceramic tile firms are one of the most important stimulators of new designs. One of the most important stimuli is the set of requirements that the marketing and commercial department laid down as general lines that designs are to follow and which are the result of analysing information from customers, observing fashion trends or investigating competitors' work. Other stimuli are the ideas that can arise inside the design, development and R&D departments, independently of the guidelines suggested by the marketing and commercial area. Novelties in manufacturing and materials technology and processes constitute another of the chief stimuli for ceramic tile firms, although a large part of this information about innovation is obtained through contacts with firms that supply components such as glazes or equipment. Lastly, there are also specific demands from commercial agents requesting a particular product to satisfy the express requirements of a certain customer.

Glaze industries have their own design departments and may offer new designs to the ceramic tile manufacturers. For this stimulator, similar stimuli were identified: the generic requirements of the market being one of the main sources of new designs. These firms each have their own commercial staff that are responsible for identifying the tendencies for each season. More and more glaze manufacturers now have their own designers, who often propose novel ways of using materials and technologies. These designs produced by the firm itself are sometimes shown at internal exhibitions or trade fairs, which are attended by tile manufacturers in order to choose the designs that best fit their needs. Another possible origin of a new design lies in the demands of customers (which in this case come from the ceramic tile manufacturers) when they commission the design of a new product.

Design offices supply tile firms with new designs, and therefore represent another stimulator of the process, but these enterprises do not centre their attention on novelties in processes and technology. Firms that produce special pieces provide tile manufacturers with decorative trim pieces. The work carried out on research into innovative technologies and processes is not as important as in glaze firms. Firms supplying trim pieces sometimes hold their own internal trade fairs so that they can offer their customers their latest designs, in the same way as glaze manufacturers. Finally, mould firms cover the needs of ceramic tile manufacturers, but do not usually propose new designs. Nevertheless, they do sometimes suggest modifications for technical reasons, for example, to make it feasible or easier to manufacture a certain product. And some of them even offer complex designs including complex relief patterns. The increasing use of complex relief patterns favours the association of the know-how of mould manufacturers and the work of firms dedicated to design.

The variety of stimulators and stimuli (Table 1) is a strength for the sector, since it therefore has a wide range of sources from which designs can be generated. This allows for the creation of competitive environments in which different design proposals compete to reach the market. Nevertheless, the strict restraints imposed by the dates of the trade fairs frequently mean that the authors of new designs do not have the flexibility and freedom they need in the process of creation; rather, they often find themselves working against the clock to get the product finished in time.

		MAIN STIMULATORS				
		Tile manuf.	Glaze ind.	Design office	Trim manuf.	Mould firms
MAIN STIMULI	Generic market and commercial requirements	✓	✓	✓	✓	
	The firm's own ideas	✓	✓	✓	✓	
	Specific demands by customers	✓	✓	✓	✓	✓
	New processes and technologies	✓	✓			✓

Table 1: The main stimulators and stimuli in the origin of Ceramic Designs

The ceramic industry is strongly market-oriented and dependent on trends. Firms must be aware of the preferences of different agents who select or filter their products (final users, dealers who commercialize the product, purchase staff in construction companies, architects, etc.). According to Blesa and Bigné [Blesa, 05], most of the activities inherent in the market-oriented business activity of tile manufacturers generate satisfaction and 'dependence' in dealers. The higher the quality of the information shared in the distribution channel is, the more willing dealers will be to accept some degree of dependence in their relations with manufacturers.

Thus, while adopting collaborative management practices, competitiveness must be improved by strengthening the interrelations among 'actors', including firms in the design chain, as well as certain kinds of customers and dealers. Creativity, especially in collaborative new product groups, is a result of communication and interactions within the team [Leenders, 03]. It has also been shown that suitable collaboration with suppliers can provide manufacturers with important advantages in R&D. At the same time, the loyalty between dealer and customer forces them to improve their relations and processes. Moreover, the relationships that arise must be integrated and improved because, despite the current high level of cooperation among firms, it is not always possible to achieve true collaboration that yields the best results.

3.3 Shortcomings in current NPD processes

One of the most apparent shortcomings identified in the analysis of current processes is the lack of strong leadership in NPD process management and, hence, the absence of detailed planning of tasks. Furthermore, nobody has been named to be in charge of them and no schedule has been agreed on to allow tasks to be carried out in parallel and deadlines to be met, i.e. it was impossible for the partner firms in collaborative projects to make forecasts that would allow them a greater capacity to react and, consequently, reduce times. Cooperation between the participants in the project was not favoured either. There was also a clear need to unify knowledge in the project in order to ensure that information is up-to-date and to prevent duplication of data.

Carrying out tasks in parallel is not encouraged and, as a consequence, the later tasks in the process are usually severely affected by the accumulated delays. This happens from the earliest stages, as those who take the initiative of launching a new design consider this information to be very likely to change and are reluctant to transmit it to other areas that need it to start on their tasks.

Certain technical shortcomings were also detected in communication and information management. Information is frequently exchanged by means of high resolution digital images, which produce large files that are difficult to transmit by simple electronic methods such as e-mail. They therefore used physical supports that were delivered by hand to a trustworthy colleague from the collaborative company, which is more costly in terms of both time and money. In addition to the technical drawbacks, firms are sometimes a little reluctant to share information with other firms, since their proposals are not usually bound by an exclusive contract, but are instead based on mutual trust. It is not unusual for the development work carried out by the different firms in the chain to be duplicated. This lack of trust is due to the fact that cooperation does not take place between organizations or IT systems, but between individual people, especially in the case of SMEs [Pouly, 09]. Regarding the four human aspects encountered by Pouly and Huber [Pouly, 09] in collaborative networks, we can say that ‘communication and mutual understanding’ take place in the sector in an informal and traditional way; ‘coordination and planning activities’ can be achieved through the use of PLM tools. ‘Knowledge sharing’ depends on ‘trust issues’, due to the configuration of the sector, which consists of similar and replaceable competitive enterprises. And when members could be competitors or work for competitors (like members bringing complementary activities), trust becomes an absolute necessity [Pouly, 05]. Within an organization, high intensity interactions can be observed between certain functions (as is the case of design and development, which practically constitute a single joint area in some firms), while in others communication is down to a minimum. This is the case, for example, of departments taking part in more advanced stages of the process such as manufacturing or logistics. Communication is also hindered by the lack of a generally agreed design terminology.

Databases containing the information related to each product or project are created with varying degrees of sophistication but are not always used by all members of staff. This often results in some information becoming duplicated or obsolete. All these activities become even more complicated in a distributed collaborative environment, where efficient communication with partners and suppliers in both a synchronous and an asynchronous manner is essential.

4 Proposed mechanisms for improving collaboration

With the aim of improving the performance of collaborative individual projects and programmes through the use of a web-based collaborative system, it was decided to manage the work to be carried out as if it were a ‘goal-oriented’ and ‘dynamic’ VO. Such a VO is established in a short time to respond to a competitive market opportunity (development of a collaborative project/programme), has a short life cycle [Camarinha, 08] and dissolves when the short-term purpose is accomplished (at the end of the launch phase). Additionally, ad-hoc collaboration processes were promoted in order to favour inter-firm and inter-department cooperation, by means of the creation of a 'network of networked teams' [McGrath, 04]. Subsets of the global project team self-organize around each project's sub-phase or task in order to complete the work. The virtual spaces support enterprises and partners with project management and collaborative engineering in inter-enterprise work environments. It does so by enabling the exchange of information (such as project plans or documents) between networked teams. We can highlight two parts: collaborative project management and design collaboration based on collaborative folders (see Figure 1).

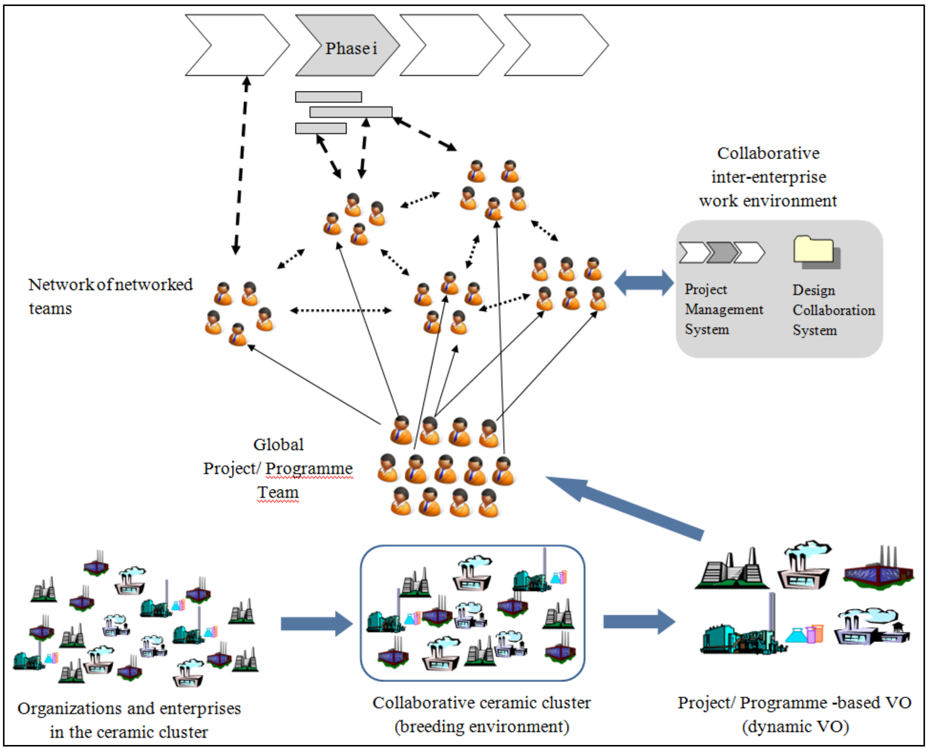

Figure 1: The web-based collaborative system supports VO's networked teams.

4.1 Project and Content Management

The structure of the projects must be common to all participants. This was achieved by dividing the work into fragments with varying levels of detail and by establishing the schedules, roles and responsibilities, and the milestones to be fulfilled, together with the information and documentation associated to each of them. This makes it possible to monitor the execution of the project and to check that the requirements are being met. In addition, certain members of staff should be able to store and access knowledge easily, so that a history is generated and continuous improvement can take place. To this end, it is essential to define project templates depending on typologies of development projects in order to obtain a knowledge repository that can be understood, used and shared [Mo, 03]. And this is even more important in collaborative environments, where knowledge is common to the participants in the supply chain. Chen [Chen, 05] finds that joint ventures encourage explicit knowledge, whereas knowledge in internal development projects can be, to a great extent, tacit. Cooper [Cooper, 03] points out that in a successful NPD process, the knowledge acquisition and development process must gradually lead to risk reduction, despite the inherent unpredictability, and therefore systems must address those factors that increase the probability of relevant knowledge being reused. Document and folder templates are a flexible way of storing and standardizing knowledge and they also allow it to be consulted, utilized, distributed and enhanced.

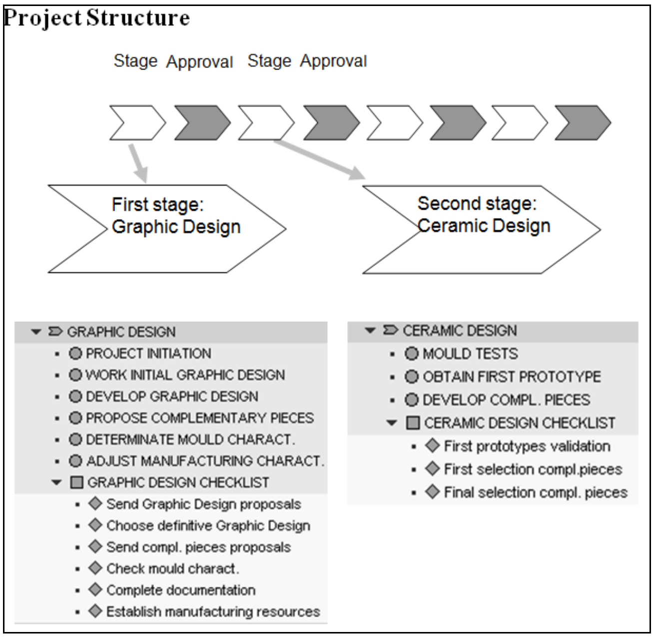

Figure 2: Partial image of a template structure in the collaborative Project Management System

In our particular PLM environment, the project templates or models were used in the web application to create certain types of elements [Agost, 06b]. Project models depend on the general characteristics of the product to be developed or the origin of the development proposal. Once the models and templates have been defined and tested, similar new projects can be easily created through simple ‘copy and paste’ operations, thus reducing set-up and management times. Figure 2 shows a partial structure of a project typology and it can be seen that the structure adopts a phase approval process [Cooper, 91, 02], [Armstrong, 01]. In each phase, a checklist is included along with the corresponding activities. Thus, it can be confirmed whether the pre-established milestones are being the achieved or not. Authorizations and permissions (reading, writing or administration) are set for team members (according to their project or programme role) to access the project elements. Templates were also used to build an information platform for project teams. Figure 3 shows the structure of general documents and graphics files for the first phase (Graphic Design Phase) of project 1. This leads to information sharing and to continuous updating of acquired knowledge.

These tools reduce the abovementioned ‘reluctance to share private information’ because they offer automatic notifications and alerts as part of their workflow utilities. Automatic alerts (by e-mail) were used in the study to inform task managers of any changes in the status of the task. Together with the possibility of creating models, there are also settings options that offer the user a wide range of alternatives for tailoring the project to meet the specific needs of each case.

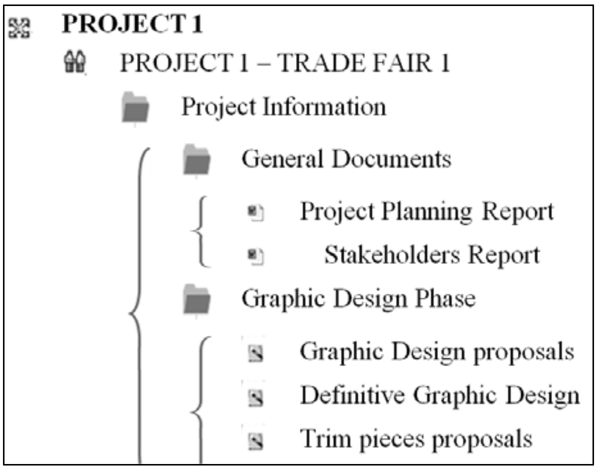

Figure 3: Partial image of a template structure in the Design Collaboration System (collaborative folders).

4.2 Roles and Collaboration Management

Our proposal for the management of the stimulators and stimuli framework involves establishing an explicit set of roles and an operating mode controlled by phase approvals. In ceramic tile design, the multidisciplinary teams in the project (technical staff dedicated to operating tasks for the development of the product) correspond to inter-firm teams that cooperate in the design of new products for a trade fair. However, these are not usually established formally and true collaboration between departments and partner organizations does not occur. The technical work done by the multidisciplinary teams must be coordinated and directed by technical coordinators, i.e. members of staff with enough knowledge and capability to make decisions. In ceramic design processes there are specialists with a thorough knowledge of the product, i.e. designers, engineers, technicians, etc., who are responsible for coordinating each stage of the project. In contrast, it is not always easy to find a figure that leads, supports and takes responsibility for the overall management of ceramic development projects. Yet, this is a fundamental role in the management of the project and is usually played by a project manager or supervisor, normally with the aid of a steering group. In our experience this role is often played down in many organizations, as in the case of the project manager. With respect to the processes of phase approval, there are two roles whose functions are currently performed in an informal manner. The first is a commission made up of a group of members of management staff, partners and/or customers, who decide on the future of each project as each stage moves on to the next, and the second is that of expert assessors, who evaluate whether milestones are being reached and generate information to lend support in decision-making.

The pilot experience did not take into account the participation of the customer in the NPD process. This specific aspect is the focus of a different study about affective design, in which preferences and subjective impressions on product design of different groups of customers of the ceramic sector (such as final users, dealers, architects, interior designers, and so on) were analysed [Agost, 10]. Lastly, attention must also be drawn to the role of quality facilitator. This person guides the process, the focus being on ensuring its quality and on directing the implementation of methodologies or tools.

The roles defined for each type of project are created in the PLM tool. The next step is to assign the particular human resources needed for each role, bearing in mind their specific capabilities and their availability. A supervisory role should be set up for each element that the project is divided into (stages, tasks, checkpoints, etc.), as well as for the project itself, to allow for ongoing monitoring of the fulfilment of requirements and deadlines. The people in charge of the elements of the project are the technical coordinators defined earlier. In the pilot study, the duties in each of the stages were entrusted to members of the technical staff, who were responsible for coordinating the work and the partial results of each stage.

The person in charge of the whole pilot project was an overall manager or administrator who carried out mainly management duties, such as creating the actual project in the application (from a previously defined template), adapting it to the specific needs (structure, roles, allocation of resources to the roles and assignation of authorizations, establishing the programme and the main goals to be accomplished), creating a virtual collaboration space for the project and defining the authorizations for it, creating phase approvals and designating those in charge, and so forth. Inter-firm multidisciplinary teams, on the other hand, were defined by setting authorizations and permissions (reading, writing or administration) for each participant and each element in the PLM tool. Multidisciplinary work is made easier by using collaborations, which are created in the web tool and linked to the corresponding element (activity or task) of the project structure. Collaborations allow documents, folders, images, etc. to be shared by participants in a task/activity by granting them permission to view, access and modify such material. It is also possible to set up discussions and other tools that can be used as a communication forum. All this is then used to configure and reinforce the vision of 'virtual work teams' in the project, as well as to facilitate communication among members of staff who are working together. Granting authorizations and permissions to certain participants generates trust.

Finally, and as mentioned above, the study also included the definition of a quality facilitator, that is to say, a general implementation supervisor, who was not necessarily involved in the daily work. Indeed, in the pilot study this job was performed by the person in charge of quality in the ceramic tile manufacturing firm.

This role was not assigned the responsibility for any tasks, checkpoints or other elements in the project. Nevertheless, it is a key figure for guiding and supporting the process, and took part in the training sessions on using the PLM tools to be applied, as well as other workshops about modelling and improving design processes, where they provided valuable information about ceramic processes and knowledge on how to improve them.

Although the pilot experience was limited to a single project, it was clear that a programme manager (in charge of the coordination of all projects developed simultaneously for the same trade fair) should have also been considered.

In sum, the definition of roles and the assignation of authorizations clearly delimit the different duties and responsibilities in the execution of each element of the project (programme) and help to achieve the trust needed for collaboration and for sharing information. Establishing a schedule for meeting goals enables an exhaustive follow-up of performance to be carried out. At the same time, the templates or models act as a basis for defining sequences in the processes, and this makes it possible to configure workflow systems that are automated to varying degrees.

5 Conclusions

We have outlined some features that greatly condition NPD projects in the ceramic tile design chain and force the development of suitable strategies. The absence of leadership in the ceramic sector may be compensated by developing a VO consisting of dynamic companies that share reference models for the management of the design processes and PLM tools that give support to collaboration and communication. Fast market changes, due to trends and fashion pressure, and the existence of different stimulators and stimuli for the origin of projects require the establishment of networked teams and the appropriate management of the project/programme roles. Our pilot study showed that design process management could be improved through these kinds of mechanisms, i.e. a sectoral reference model and PLM tools, tailored to the particular circumstances of this kind of clusters by the use of templates. This experiment has proved efficient, since it allowed us to determine why and where the process should be enhanced; i.e. which obsolete methodologies could be converted into computer-aided processes. Once the main obsolete methodologies and singularities of ceramic tile design process had been detected and the new approach proved efficient, developing new experiments could only help in finding new niches of future developments that would fall clearly beyond the scope of the current research.

If PLM tools are adjusted to a sectoral reference model designed to fit the necessities of a certain domain and enterprise type, they may provide support for the collaborative management needs in projects for developing new products by offering a global solution that includes structural, planning, control and general management aspects in a simple environment. The flexibility of the applications used makes it clear that not only do they fit the requirements of the project, but they also contain functionalities that go beyond that, by offering interesting possibilities for the future of the continuous improvement of products and processes.

Moreover, the templates proposed to adjust the design-aimed PLM tool to a sectoral reference model are helpful, as they make it possible to delimit the diffuse roles detected in the analysis and to manage processes by setting authorizations and permissions. They also force explicit phase approvals, which were considered critical to improve a dynamic process where different projects are carried out simultaneously for a trade fair. In addition, they are easy to use as they are collaboratively predefined by the academic partners and later used by the industry partners with few or no changes.

Acknowledgements

This work was partially supported by the Spanish Ministerio de Ciencia y Tecnología; Dirección General de Investigación under the Plan Nacional de I+D+i programme for Research Promotion (Project DPI2002_02141. CE-TILE). We also acknowledge the help given by Capgemini España S.L.U., TAU Cerámica S.A., Esmalglass S.A., Macer S.A. and Cerámica Kersa S.L. in the new ceramic product design and development pilot experience, which was carried out within the framework of the project.

References

[Abecassis, 06] Abecassis-Moedas, C.: Integrating design and retail in the clothing value chain: An empirical study of the organisation of design, International Journal of Operations and Production Management, 26 (4), 412-428 2006.

[Agost, 06a] Agost, M.J.: Metodologías para la gestión de procesos de desarrollo de nuevos productos en entornos colaborativos. Aplicación a la cadena de diseño cerámica, Research report, Universitat Jaume I 2006.

[Agost, 06b] Agost, M.J., Romero, F., Vila C., Company, P.: Use of Patterns for Knowledge Management in the Ceramic Tile Design Chain, Cooperative Design, Visualization, and Engineering, Lecture Notes in Computer Science, 4101, 65-74 2006.

[Agost, 10] Agost, M.J., Vergara, M.: Taking the Customer into Account in Collaborative Design, Cooperative Design, Visualization, and Engineering, Lecture Notes in Computer Science, 6240, 174-177 2010.

[Akgün, 07] Akgün, A. E., Byrne, J. C., Lynn, G. S. and Keskin, H.: New product development in turbulent environments: Impact of improvisation and unlearning on new product performance, Journal of Engineering and Technology Management, 24 (3), 203–230 2007.

[Armstrong, 01] Armstrong, S.C.: Engineering and Product Development Management. The Holistic Approach. Cambridge University Press 2001.

[Aziz, 05] Aziz, H., Gao, J., Maropoulos, P. and Cheung, W. M.: Open standard, open source and peer-to-peer tools and methods for collaborative product development, Computers in Industry, 56, 260-271 2005.

[Blesa, 05] Blesa, A., Bigné, E.: The effect of market orientation on dependence and satisfaction in dyadic relationships, Marketing Intelligence and Planning, 23 (3), 249-265 2005.

[Camarinha, 05] Camarinha-Matos, L.M., Afsarmanesh, H. Collaborative networks: A new scientific discipline. Journal of Intelligent Manufacturing 16 (4-5), 439-452 2005.

[Camarinha, 07] Camarinha-Matos, L.M., Afsarmanesh, H. A comprehensive modeling framework for collaborative networked organizations. Journal of Intelligent Manufacturing 18 (5), 529-542 2007.

[Camarinha, 08] Camarinha-Matos, L.M., Afsarmanesh, H. On reference models for collaborative networked organizations. International Journal of Production Research 46 (9), 2453-2469 2008.

[Camarinha, 09] Camarinha-Matos, L.M. Collaborative networked organizations: Status and trends in manufacturing. Annual Reviews in Control 33 (2), 199-208 2009.

[Chang, 06] Chang, C.M.: Web-based tools for product development, International Journal of Product Development, 3 (2), 167-180 2006.

[Chen, 05] Chen, S.: Task partitioning in new product development teams: A knowledge and learning perspective, Journal of Engineering and Technology Management, 22 (4), 291-314 2005.

[Chiva, 04] Chiva, R., Alegre, J.: Design management approaches in the Spanish ceramic sector: a comparative case study, International Journal of Product Development, 1 (2), 215-233 2004.

[Claros Salinas, 08] Claros Salinas, M. P., Prudhomme, G., Brissaud, D.: Requirement-oriented activities in an engineering design process. International Journal of Computer Integrated Manufacturing, 21 (2), 127-138 2008.

[Cooper, 03] Cooper, L. P.: A research agenda to reduce risk in new product development through knowledge management: a practitioner perspective, Journal of Engineering and Technology Management, 20 (1-2), 117-140 2003.

[Cooper, 02] Cooper, R.G., Edgett, S.J., Kleinschmidt, E.J.: Optimizing the stage-gate process: what best-practice companies do-I, Research Technology Management, 45 (5), 21-27 2002.

[Cooper, 91] Cooper, R.G., Kleinschmidt, E.J.: New product processes at leading industrial firms, Industrial Marketing Management, 20 (2), 137-147 1991.

[Damanpour, 06] Damanpour, F., Wischnevsky, J. D.: Research on innovation in organizations: Distinguishing innovation-generating from innovation-adopting organizations, Journal of Engineering and Technology Management 23 (4), 269–291 2006.

[Dickson, 95] Dickson, P., Scheier, W., Lawrence, P., Hytry, R: Managing Design in small high-growth companies, Journal of Product Innovation Management, 12 (5), 406-414 1995.

[Duque, 08] Duque, R., Gallardo, J., Bravo, C., Mendes, A.J.: Defining Tasks, Domains and Conversational Acts in CSCW Systems: the SPACE-DESIGN Case Study, Journal of Universal Computer Science, 14(9), 1463-1479 2008.

[Flor, 05] Flor, M., Oltra, M. J.: The influence of firms' technological capabilities on export performance in supplier-dominated industries: The case of ceramic tiles firms, R&D Management, 35 (3), 333-347 2005.

[Geyer, 08] Geyer, W., Silva-Filho, R.S., Brownhotz, B.,Redmiles, D.F.: The Trade-Offs of Blending Synchronous and Asynchronous Communication Services to Support Contextual Collaboration, Journal of Universal Computer Science, 14(1), 4-26 2008.

[Gutwin 08] Gutwin, G., Greenberg S., Blum, R., Dyck, J., Tee, K., McEwan, G.: Supporting Informal Collaboration in Shared-Workspace Groupware, Journal of Universal Computer Science, 14(9), 1411-1434 2008.

[Harmancioglu, 07] Harmancioglu, N., McNally, R. C., Calantone, R. J., Durmusoglu, S.S.: Your new product development (NPD) is only as good as your process: an exploratory analysis of new NPD process design and implementation, R&D Management, 37 (5), 399-424 2007.

[Janev, 05] Janev V. and Vranea S. The Role of Knowledge Management Solutions in Enterprise Business Processes. Journal of Universal Computer Science, 11 (4), 526-545 2005.

[Leenders, 03] Leenders, R.Th.A.J., van Engelen, J.M.L., Kratzer, J.: Virtuality, communication, and new product team creativity: a social network perspective, Journal of Engineering and Technology Management, 20 (1-2), 69-92 2003.

[McIvor, 06] McIvor, R., Humphreys, P., Cadden, T.: Supplier involvement in product development in the electronics industry: A case study, Journal of Engineering and Technology Management, 23, 374–397 2006.

[McGrath, 04] McGrath, M.E.: Next Generation Product Development. How to Increase Productivity, Cut Costs, and Reduce Cycle Times. McGraw-Hill, New York 2004.

[Mo, 03] Mo, J.P.T., Zhou, M.: Tools and methods for managing intangible assets of virtual enterprise, Computers in Industry, 51 (2), 197-210 2003.

[Murman, 02] Murman, E. et al.: Lean Enterprise Value: Insights from MIT's Lean Aerospace Initative. Palgrave, New York, 2002.

[Oakey, 07] Oakey, R.: Clustering and the R&D management of high-technology small firms: in theory and practice, R&D Management, 37 (3), 237-248 2007.

[Pouly, 09] Pouly, M., Huber, C.: Collaborative Networks: Human Aspects and Corresponding IT support. In Proc. 13th International Conference on Computer Supported Cooperative Work in Design. April 2009, 576-581 http://www.cscwd09.cl/

[Pouly, 05] Pouly, M., Monnier, F., Bertschi, D.: Success and failure factors of collaborative networks of SME, In Proc. 6th working conference on Virtual Enterprises. September 2005, 597-604.

[Romero, 08] Romero, F., Company, P., Agost, M.J., Vila C.: Activity Modelling in a Collaborative Ceramic Tile Design Chain. An enhanced IDEF0 approach, Research in Engineering Design, 19 (1), 1-20 2008.

[Simone, 97] Simone C., Divitini M. Ariadne: Supporting Coordination through a Flexible Use of the Knowledge on Work Processes. Journal of Universal Computer Science, 3 (8), 865 - 898 1997.

[Stokes, 01] Stokes, M.: For MOKA consortium. Managing Engineering Knowledge. MOKA: Methodology for Knowledge-Based Engineering Applications. ASME Press, American Society of Mechanical Engineers New York 2001.

[Swink, 06] Swink, M., Talluri, S., Pandejpong, T.: Faster, better, cheaper: A study of NPD project efficiency and performance tradeoffs, Journal of Operations Management, 24, 542-562 2006.

[Tomek, 01] Tomek I. Knowledge Management and Collaborative Virtual Environments Journal of Universal Computer Science, 7 (6), 458-471 2001.

[Vila, 05] Vila, C., Romero, F., Galmés, V., Agost, M.J.: Collaborative Solution for Cooperation, Coordination and Knowledge Management in the Ceramic Tile Design Chain, Cooperative Design, Visualization, and Engineering, Lecture Notes in Computer Science, 3675, 86-93, 2005.