INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'07
28 - 31 AUGUST 2007, CITE DES SCIENCES ET DE L'INDUSTRIE, PARIS, FRANCE

ANALYSIS AND IMPROVEMENT OF THE PROCESS OF PARTICIPATIVE INNOVATION FOR PRODUCT DESIGN: TOWARD AN INDUSTRIALISED PROCESS

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ABSTRACT

In a context of international competition, innovation constitutes one of the keys for the development of the companies. We are interested in a particular form of organization: the participative innovation aiming at the involvement of all the actors of the enterprise. We analyse the current process of participative innovation called "helping push" in a large European railway company in order to identify its limits.
Then we propose a change in the current method to allow the absorption of a much larger quantity of innovations. The objective is to transform a "case by case" organization to a real industrial one. By relying on the work in enterprise modelling, BPM (Business Process Management), information systems design, and management of innovation, a new organization is proposed and formalized.
This new organization is based on the establishment of a technical committee charged to follow up the requests, but also on a committee of experts whose role is to appraise the potential innovations and on a group of sponsors who will decide to put money into the realization of the project, and finally on external partners who can intervene in supporting. The whole of the organization works according to the rules of a management committee. Concrete examples of such innovating projects are given.
A synthetic view about the information system developed to support this new organization is also presented. In conclusion, the generic nature of the proposed organisation makes it applicable in other industrial fields.

Keywords: design engineering, innovation, process modelling

1 INTRODUCTION

In a context of international competition, innovation constitutes one of the keys for the development of companies. Various types of organizations can be set up to allow the emergence and materialization of innovations, as for example the innovation cells which appeared in the large companies in the nineties [1]. Here, we deal with another form of organization: participative innovation the objective of which is to involve all the actors of the enterprise in the search for innovation of products or services. This form of organization particularly is applied in a large European railway company.
The management of the company recently made participative innovation a genuine tool for its human resources policy, a tool also included in the strategic project of the company. It is used as a vehicle for both external and internal communication in order to contribute to the evolution of the culture of the company. One of the elements of the participative innovation is the device called "helping push", more specifically dedicated to the prototyping and design of products. The strong technical culture of the actors potentially enables them to be a force of proposal in this step of continuous improvement. The development of this device was initiated by the Innovation and Research Department. Its role is to work out the research and innovation policy. The Innovation and Research Department can support an idea through technical expertise, through help for the development of the project or financial aid with a budget of about 3000 euros for prototyping. So, by relying on the network of the company's researchers and experts, it performs expertise and technical aid for the innovators.
Sensitizing actions within this participative innovation program aim at encouraging the actors to suggest ideas improving what exists or to offer new products or services.

Concretely, the actor (the innovator) deposits a file with a local organizer. This file is closely examined to appraise the range of the innovation (local, regional or national level) and the potential "customer" (it is one of the departments of the firm) concerned. If the opinion is favourable, the innovator is given a year to create a prototype or a feasibility survey, according to the extent of the innovation.
We propose a formalization of this process, on an organizational and functional level. This work makes it easier to understand the process of participative innovation, so that its management is more efficient. The actual organization entails bottlenecks that limit the possibility to increase the number of innovations. Moreover, the role of the different actors has to be clarified.
Combination of creativity methods with efficient evaluation techniques and a solid definition of the context are supposed to increase the number of innovative ideas.
The whole process can be driven by an adapted information system covering the whole life cycle of an idea, from the emergence of the idea to the implementation through expertise and the help of a "sponsor".
After a presentation of innovation and its management (part 2), we will develop in part 3 a method to reorganize participative innovation. This method relies on functional analysis, works on firm modelling, and the information systems developed to support this new organization [2], [3]. It is applied to the case of a large European railway company. Part 4 presents some specifications for a software (data processing) tool concerning this new organization and based on the UML language [4]. Part 5 presents some examples of product innovations as illustrations of this approach.

2. INNOVATION AND ITS MANAGEMENT

2.1. Definitions of innovation

According to Romelaer, "innovating is developing a new product, a new service or a new way of organizing" [5]. Innovation can deal with a process or a product. There are different kinds of innovations according to the sector they belong to, their novelty degree or their aspect, technological or not. Innovation is a polysemic term [6]. Without pretending to have an exhaustive literature review, we have selected several definitions to explain our statement.
Durand [7] distinguishes two types of innovation: technological innovation concerning the product concept offered to the customer or the manufacture process and organizational innovation, which can be defined as "organizational change process with the introduction of different production methods or administrative processes" [8]. Innovation is mostly mixed; it "generally combines technological aspects (product/process) and organizational aspects" [9]. According to Kimberly, innovation can have different natures, administrative or technical, product and/or process [10]. Norbert Thom distinguishes three types of innovation with different goals: product innovation, process innovation and social innovation. Social innovation requires planned improvements on an individual level as well on an inter-individual level. An innovation is first a new idea. A "new" idea can be a recombination of old ideas as long as the idea is perceived as new by people within the organization. It can be considered as an innovation even if to others it is an "imitation of what 'may' exist elsewhere" [11]. Slappendel notices that innovation is used to refer to the process which makes it possible to create, develop and reinvent new ideas, new objects and new practices. This process covers design and development, adoption, implementation and diffusion periods [12].
As developed just before, these definitions of innovation are based upon the results, the innovation mindset and the process of innovation. Our contribution is focused on the process of innovation.
Participative innovation is not so much evoked. Durieux defines it as "an innovation proposed, out of a mission, by actors of the firm. More complete than a simple suggestion, this sort of innovation requires the innovator's active participation all along the development process" [13]. Durand mentions criteria which can foster the diffusion of innovation such as confidence, solidarity, listening skill and enthusiasm [7]. The innovator will often have to face the established order to start innovating. According to Alter, as long as innovation has not entered the social system, it is a creation, without diffusion [14].

2.2. Do certain organizations foster innovation?

Mintzberg has proposed a classification for structures (simple structure, mechanist bureaucracy, professional bureaucracy, adhocracy). Adhocracy is supposed to be the most facilitating organizational form to innovate [15]. Burns and Stalker distinguish mechanist structure (or bureaucratic) and organic structure. Mechanist structure is considered as adapted in a stable environment for routine and standardized tasks whereas organic structure is more appropriate when there is commercial or technological instability. On the organizational level, the necessity for a less formalized structure, less bureaucratic is supposed to foster the autonomy and the creativity of the actors [16], [17]. In the mechanist form, Burns and Stalker enhance the specialization of functions in the mechanist model. The organic form is supposed to be more appropriate to innovate, because it is more adaptable and innovating in changing contexts than the mechanist form.

Concerning the case of the railway company, we can consider it as a mechanist form in the sense of Burns and Stalker and a bureaucratic structure in the sense of Mintzberg, which a priori are not the best ones for innovation. In organizations, innovation can be helped by other means of coordination, such as communities of practice [18]. Participative innovation has been applied for more than 10 years in this company. It is a means to foster innovation initiatives.

2.3. Favourable factors and obstacles in a bureaucratic organization

Innovation in well established firms is a difficult process [19], [15], [14]. According to Alter, innovation is antagonistic and complementary to organization. The members of an organization want to respect established routines to legitimize the organization to the eyes of the different members [20], [21]. Human beings tend to reject ideas which do not respect their beliefs; it is therefore difficult to convince the members of an organization of the value of an innovative idea. Alter is of the opinion that "innovation is based on 'entrepreneurs', independent from economic constraints and hierarchical position". They do a 'creative destruction', spotting the old to the benefit of the new. The 'exploiters' (operating staff) of the organization resist to achieve the defined estimates because they are not able or refuse to imagine new forms. To them, innovation is too intuitive, can be transgressed too easily, and cannot be sufficiently foreseen. Moreover, people with power tend to resist changes which could take them away from power [22].

According to Durand, "the promotion of innovation can o work on the culture of the organization to try to steadily implement the innovator as a symbol for future, but also to promote the following standards: confidence, solidarity, listening and enthusiasm which appear to be important for innovation" [7]. Our research is part of this perspective to better understand the context of a participative innovation device.

3 METHOD FOR ANALYSIS AND DESIGN OF THE ORGANIZATION

The proposed method follows the steps Figure 1, detailed hereafter; two supplementary steps (to put the organization operational and to manage the organization) aren't represented because they are off the subject.

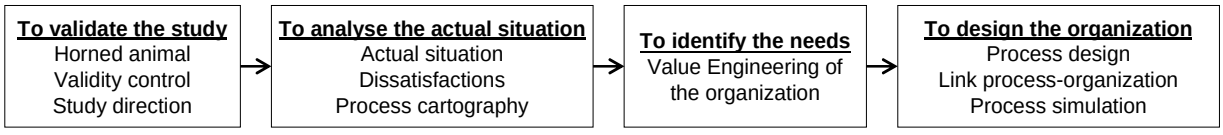


Figure 1. First steps of the analysis and organization design process

3.1 To validate the study

Before the beginning of the study, it is desirable to validate the interest of the study itself. Indeed, the risk to invest in a study for which the client, and therefore the interest, is not clearly identified is real; this is particularly true in an important enterprise in which decision circuits are not always easy to identify by an external contributor.

We use for that the "horned animal" APTE® formalism from Value Analysis [24] applied to the study itself; see Figure 2. APTE® [23] is a method of Value Analysis that introduces two additional diagram: the "horned animal" (which allow the formalization of a subject: (i) who it helps, (ii) on what it acts, (iii) with what intention) and the "octopus" (in order to describe the elements of the subject's environment, the transfer functions between two elements by the mean of the subject, and the

constraint functions which the subject has to respect for an element of environment). The beneficiary entity is thus identified; the subject and objective of the study are formalized.
The validity control aims at the determination of the cause of the study (why?), which objectives it aims for (for what?), what are the risks of evolution or disappearance of the need, in order to conclude on the necessity or not to carry out the study.
In the case of the enterprise examined, the study validation has allowed the identification of a precise contact (Innovation and Research Department, IRD) and the definition of the study direction (see Table 1).

Table 1. Study direction

Project origin	Innovative participation strategy
Decision-maker	IRD director
Delay	Study: 3 months Organization operational: 6 months
Objectives	To treat 1000 “helping push” per year To improve the follow-up of the demands To transform 60% of prototypes in operational realization

The last objective is important to insure the success of the participative innovation: when only a prototype is built, it is actually difficult to find a client for an innovation i.e. an operational direction which appropriates the prototype and invests in order to develop and to industrialize the solution in the enterprise.

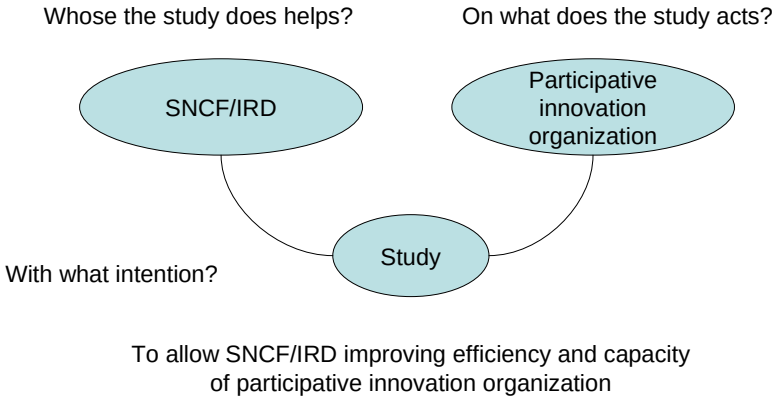


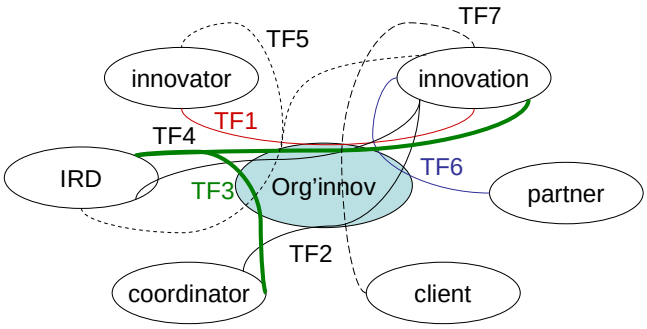
Figure 2. “Horned animal” of the pre-study for the enterprise under study

3.2 To analyze the actual situation

In order to design an efficient organization of participative innovation, some specificities of the enterprise have to be taken into account such as its culture, its structure (role of the actors, relations between actors…), its resources (workers, money, machines, materials, information). First, a preliminary observation and a comprehension of the context are necessary.
Second, the interviews with key actors of the enterprise make it possible to identify dissatisfactions and to carry out causal analysis of malfunctioning.
Finally, the process cartography is done: production process (here the process that allows transforming a potential idea in operational innovation), support process (that gives resources) and running process (that manages the whole of the process).
This cartography is used for flows analysis (volume, time, added value…); it is possible so to highlight bottlenecks and activities with low added value.
In the case of the studied enterprise, the analysis of the actual situation (no detailed here) highlighted dissatisfactions causes, as the difficulty for certain innovator to formalize a demand, or the worry for the superior of an innovator to maintain his/her hierarchical position in case of default of information.

3.3 To identify the needs

This step is done with a value engineering approach using the "octopus" APTE® formalism applied to innovative organization (Figure 3).



TF1 : to help the innovator to express, to develop and to follow his/her innovation
TF2 : to allow the coordinator assessing the scope and the need of help for innovation development
TF3 : to make the communication of innovation to IRD easier
TF4 : to allow the IRD assessing the innovation
TF5 : to help IRD experts to advise and support the innovator in the innovation development
TF6 : to ensure partner contribution in innovation development
TF7 : to assess and to apply the innovation

Figure 3. Partial "octopus" of the new organization promoting innovation

The transfer functions (TF) make the connection between several elements of the environment, and the constraint functions (CF) represent a limit of the organization design due to an element of the environment.

Each function is then formalized, its appreciation criteria (that allow its characterization), levels (to reach in order to satisfy the function) and flexibilities (that specify if a criterion may be relaxed) are defined; these functions can be represented in a matrix of functions (see Table 2).

Table 2. Extract of matrix of functions the new organization must satisfy

Function	Concerned elements of environment	Description	Criteria	Levels	Flexibility
TF7	client innovation	To evaluate and concretize the innovation	Success	Rate > 60% Number > 600	low low
CF1	innovator	To allow each actor of the enterprise to formulate an innovation	Origin of the demands	Ratio Nb of demands / Nb of persons = the same for each category	+/- 15%

The CF1 constraint (Table 2) implies that each person in the enterprise has the same facilities for ideas proposals. Now, even if a lot of employees use currently computers, it is not the case for all of them. A large proportion has difficulties to submit their ideas in written form.

The new organization must take into account these disparities and has to propose for example the intervention of a "letter-writer" for certain employees.

An indicator will be created in order to manage this function and to record the increases realized.

3.4 To design the organization

The design of the organization is done by applying a process approach [24] in a collaborative manner, with the implication of the enterprise staff:

1. To identify, to describe the process and to decide objectives.
2. To measure and to analyse the process: to fix indicators, to monitor, to assess the maturity.
3. To improve: to identify and to do actions for improvement.

4. To assess and to consolidate: to assess actions efficiency and to generalize solutions.

The activities of the process are clarified (input, output, needs of the client, needs of the enterprise, responsibilities, resources, monitoring); the process are crossed with the enterprise organization in order to clarify the responsibilities.
The process is simulated in order to validate the delays and to plan the needed resources.
An example of such a crossing is given Figure 4.

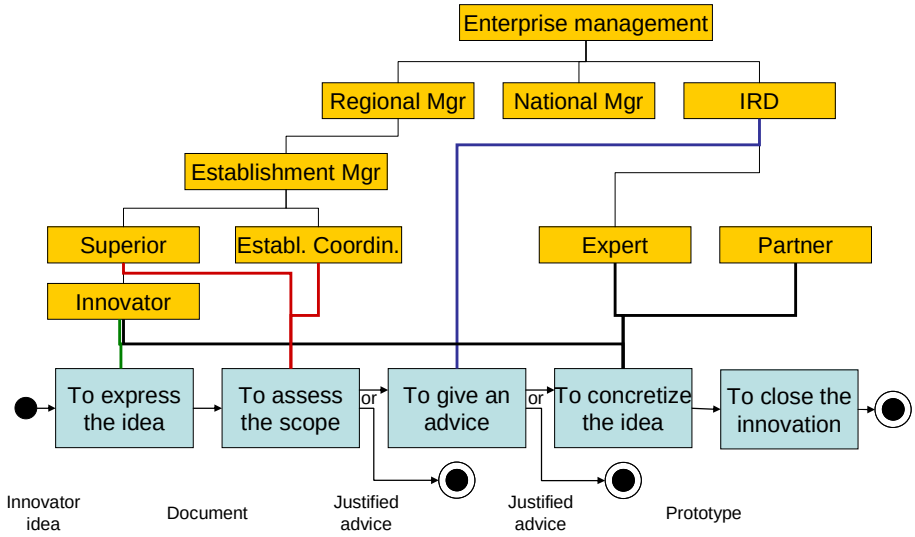


Figure 4. A process for the concretization of an idea crossed with the organization

4 SUPPORT TOOL SPECIFICATION

After defining the organization, an information technology tool has to be developed in order to increase the communication, capitalize the innovations and simplify the process management.
The UML use-case diagram in Figure 5 presents the services given by the system to the main actors that intervene in the process [4].

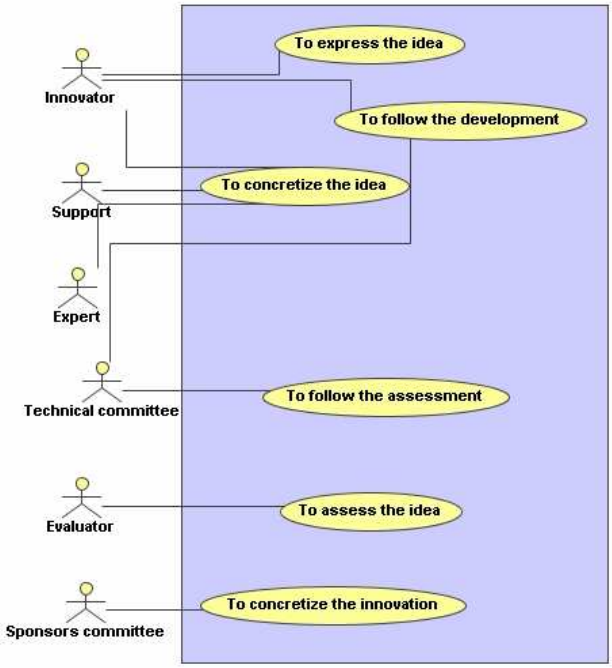


Figure 5. UML use-case diagram for the process of idea concretization

Figure 6 is a UML class diagram for the typing and the evaluation of an idea. Several innovators can be at the origin of the idea that is formalized as a demand; nevertheless, there is only one leader.
A demand is evaluated by at least two evaluators; they are designed by the coordinator of the Technical Committee.
Each evaluator completes a form that is passed to the coordinator (and not directly to the innovator). The coordinator makes a synthesis of the evaluations and decides if the demand is or not acceptable; he writes the final evaluation that is handed over to the innovator.

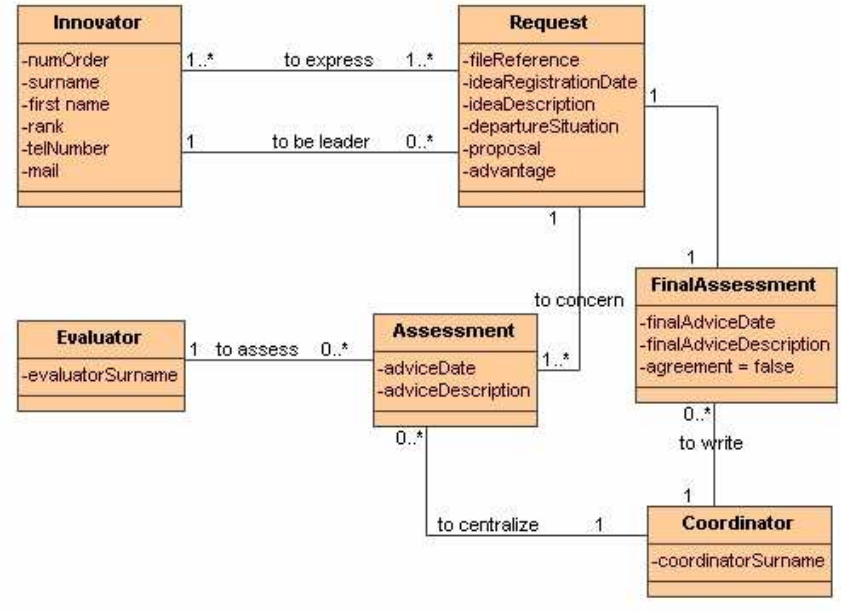


Figure 6. UML class diagram for idea typing and evaluation

A prototype of software is developed in order to show the feasibility of this new organization. One can notice that it is generic: the classes should be the same in another company.

5 CONCRETE INNOVATIONS EXAMPLES

Linked to the previously described organization, an "enriched" design life cycle has been proposed [25], [26], [27]. This design life cycle includes several phases: requirement definition (need identification, information gathering, and functional analysis), innovation and selection (research of innovative ideas, potential solutions evaluation, and choice of a solution) and product design (return to a more traditional design process from the product specifications to the final product).
Several studies have been made for the enterprise under study using the proposed method; two examples are briefly presented hereafter.
The first project is relative to the picking up of metallic debris coming from the rotating parts and braking systems of the trains. Due to this debris, electric circuit continuity appears between two successive sections of tracks that must be isolated (normally, the electric contact is only established during the metallic wheel passage). In consequence, traffic lights are closed at inopportune moments.
The specifications given by the company were oriented towards a particular solution with an electromagnet. The study allowed identifying the true need – to insure the traffic regularity for passenger satisfaction – and suggested several innovative solutions. One of these solutions has been pursued in a detailed way: a mixed throw and suck up system moved close to the track.
The second example concerns a problem of secondary railway lines: wagons have to be moved to maneuvers on small distances. Actually, the employees use a locomotive, but this causes a loss of time and is expensive. The solution under development is a light autonomous conveyor that tows the wagon.
These two cases have been studied with the "Creassiste" tool [25]. They have been developed in collaboration with project teams of students from Ecole Centrale de Lille until the step of the prototype.

6 CONCLUSION

Engineering design is a process which includes several dimensions: actors, enterprise culture, methodological aspects, tools, organization…

In complement of previously proposed methods, this contribution focuses on the organizational viewpoint. Based on sociological works, business process modeling, value engineering and unified modeling language, a method for analysis and design of an organization for the participative innovation development has been described.

The process can allow innovative ideas emergence and development, notably by dissatisfactions assessment.

This approach has been applied in a large railway enterprise. Several benefits can be noticed: the organization has been formalized and upgraded, the demands are dealt with more quickly and a support tool has been created in order to improve the management of innovation.

The future works will be about the application of this method in other enterprises, in order to validate the generic aspect of the method.

ACKNOWLEDGEMENTS

Mr Adrien DERUMIER, Direction de l'Innovation et de la Recherche SNCF.

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