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RISK MANAGEMENT IN NEW PRODUCT DEVELOPMENT PROJECTS: TAKING CREATIVITY INTO CONSIDERATION

Severine Sperandio, Vincent Robin and Philippe Girard
IMS-LAPS, University of Bordeaux, FRANCE

ABSTRACT
Innovation or New Development Product (NPD) corresponds to the application of new and creative ideas. The innovation process is always a rhythm of search and selection, exploration and synthesis, cycles of divergent thinking followed by convergence. It typically involves creativity, but is not identical to it: innovation involves acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. Many NPD projects deviate from their initial target due to modifications or changes to customer needs as well as internal or external constraints. Other NPD projects may be simply stopped due to uncontrolled parameters and unidentified constraints arising from various processes within the NPD project such as the product design process or the supply chain design. In addition, since innovation is a function of creativity, NPD projects success or failure is dependent on creativity. This paper aims to establish a risk management procedure for NPD projects, including the risk due to creativity, in order to facilitate decision-makings of senior managers and also improve global performances of companies.

Keywords: Risk management, Innovation, New Development Product, Risk taking, Creativity.

1 INTRODUCTION
In response to the evolutions of its environment and possible internal dysfunctions, a company evolves thanks to strategic decisions then actions on its constitution, on the products manufactured and / or the network to which it belongs (suppliers, subcontractors, customers, etc.). Hence, it is now accepted that innovation is key to any company's long term success. But what does innovation really mean? The term innovation means a new way of doing something. It may refer to incremental, radical, and revolutionary changes in thinking, products, processes, or organizations. A distinction is typically made between Invention, an idea made manifest, and innovation, ideas applied successfully [1]. Innovation is also the act of introducing something new. According to J.L. Byrd, "the act of introducing" is akin to taking risk and "new" is about creativity [2]. Therefore, innovation involves creativity, but is not identical to it: innovation involves acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. Many NPD projects deviate from their initial target due to modifications or changes to customer needs as well as internal or external constraints. Other NPD projects may be simply stopped due to uncontrolled parameters and unidentified constraints arising from various processes within the NPD project such as the product design process or the supply chain design. Consequently, innovation leads to investing in a project by giving up the idea of an immediate profitability and by accepting a certain risk. Before employing their resources, companies must also wonder about their financings and take time to reflect about their strategy. Project success or failure depends on how and by whom it is determined [3]. Risk processes do not require a strategy of risk avoidance but an early diagnosis and management [4]. In the case of NPD projects, it is necessary to do an early diagnosis and management considering the creativity. This paper aims to establish a risk management procedure for NPD projects, including the risk due to creativity, in order to facilitate decision-makings of senior managers and also improve global performances of companies.
The paper is organized as follows. In Section 2, concepts of innovation are introduced then a distinguishing between innovation and creativity is discussed. After is detailed where and when in the design process does creativity occur. Risk factors due to innovation and their impact on the design

process are analyzed in Section 3, and then categories of NPD project failures are proposed. Impacts of problems due to creativity are also examined in Section 4. Some conclusion remarks and discussions are provided in the last section.

2 INNOVATION AND CREATIVITY

2.1 Innovation

Innovation corresponds to the application of new and creative ideas. It is generally understood as the successful introduction of a new thing or method. Innovation is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services [5]. The innovation process is always a rhythm of search and selection, exploration and synthesis, cycles of divergent thinking followed by convergence [6]. It includes several phases:

- Idea generation: Here, managers have to analyze and audit the company (identification of strengths and weaknesses, internal factors) and its environment (identification of opportunities and threats, external factors). Used in a business context, such identifications help the enterprise find a sustainable niche in the market: they uncover opportunities that the enterprise is well placed to take advantage of, and by understanding its weaknesses, it is possible to manage and eliminate threats that would otherwise catch it unawares. It is also the first stage to help managers to focus on key issues and therefore define a new economic role for the enterprise. Here, managers can use the SWOT matrix, which is a proactive analysis tool allowing a decision maker to anticipate the risk factors even before they happen [7].
- Feasibility: the purpose of the feasibility phase is to check that theoretically the project is coherent with the strategy and the means of the company. It is thus a question of carrying out technological, commercial, economic, juridical and organizational feasibilities. At the end of the feasibility phase, the business plan is passed on to underlings of the project. The business plan is a decision-making tool, which contains whatever information is needed to decide whether or not to pursue the NPD, the reasons why this NPD believed attainable, and the plan for reaching this goal. It also contains background information about the organization (human and technical resources) attempting to reach it.
- Development, Implementation and Launch.

2.2 Distinguishing between creativity and innovation

Creativity is the ability to produce ideas / artifacts that are novel, surprising, and valuable [8]. Creativity is an integral part of the engineering design process, its presence often being the major influence on the impact of a product [9]. Also, without some element of creativity in design there is no potential for innovation. Innovation typically involves creativity, but is not identical to it: innovation involves acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. In others words, all innovation begins with creative ideas. Innovation is the successful implementation of creative ideas within an organization. In this view, creativity by individuals and teams is a starting point for innovation; the first is necessary but not sufficient condition for the second [10]. Creativity is typically used to refer to the act of producing new ideas, approaches or actions, while innovation is the process of both generating and applying such creative ideas in some specific context. In the context of an organization, therefore, the term innovation is often used to refer to the entire process by which an organization generates creative new ideas and converts them into novel, useful and viable commercial products, services, and business practices, while the term creativity is reserved to apply specifically to the generation of novel ideas by individuals or groups, as a necessary step within the innovation process.

The creative process is a balance of the intuitive and the rational. Also, there are two approaches to describe creativity: the romantic and the non-romantic approach. The romantics take a more spiritual view of creativity where it is viewed as a mysterious and subconscious process [11] [12]. Shneiderman offers three different perspectives of non romantic style creativity [13]: situationalist, structuralist and inspirationalist. Situationalists view of creativity moves away from the individual perspective of creativity and views creativity as more of a social process [14] [15]. Structuralists apply a more systematic and methodological approach to creativity [13][14]. Creative process models in this form have been described by several authors [8] [16] in terms of the exploration and transformation of conceptual spaces. Finally, Inspirationalists focus on the individuals coming up with ideas in a fashion

such as the 'eureka' moment – a sudden change in perception giving rise to an idea from the subconscious. Such a creative process model which fits in with this view is Wallas's [17] with his stages of incubation and illumination. This is the most recognized of all creative process models. It is a linear process and contains no feedback loops. Hereafter are detailed the four stages of this creative process:

- Preparation: This regards the information and knowledge inputs into the process, but also the problem structuring and sense making. This is the somewhat overlooked stage of the process that this research hopes to improve. Its relevance is obvious in engineering design as it parallels the common, Problem Definition/Clarification of task stage of the renowned systematic processes.
- Incubation: A relatively unexplained cognitive process where information is left for a period of time to either: remove mental bocks (e.g. writers block) resulting in the assimilation of an adequate association (illumination), and/or, waiting for stimulating information (e.g. waiting for inspiration) to arise and spark an adequate association [18]. This stage of the creative process does not always occur, or may occur but instantaneously. The incubation period may be the difference between producing creative solution and producing routine solutions.
- Illumination: This is not so much a stage of the creative process but rather an output, when a promising idea has been realized. It is associated with a feeling of excitement and accomplishment. This is often referred to as the 'Eureka' or 'Ah ha' moment. In the authors experience this is not always so clear cut. Often the Ah ha feeling can come later when understanding an idea. It is difficult to distinguish between the illumination experience that occurs in a creative process (when something is created i.e. a concept) and the illumination when gaining understanding i.e. when solving a logic puzzle, a mathematics problem or understanding a problem structure or evaluation method.
- Validation: This is where the solution from the illumination phase is checked for its appropriateness. This phase is less important with regards to this research as it lies after the process of idea generation. The validation, evaluation and testing of idea/concepts is easier and less mystical than the process of producing them.

2.3 Exercise points of creativity in the design process

Pahl and Beitz split the design process into four main phases which have been translated as: product planning and clarifying the task, conceptual design, embodiment design and detailed design [19]. Hereafter are joined the design and creativity processes at the common first phase: the "clarification of task" phase [9] (Figure1).

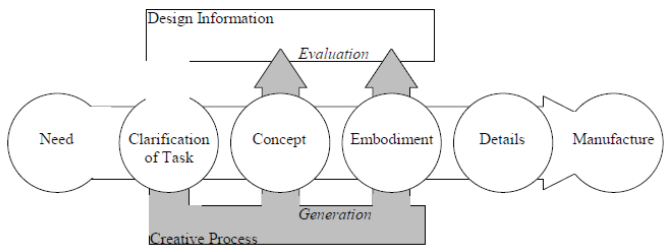

Figure 1. Integrated Creative-Design Process Model [9]

It is emphasized that the creative process manifests in both the conceptual design phase and the embodiment design phase. Each loop of the creative process within these phases will first generate information as an idea, and then evaluate it which adds to the design information and may re-clarify the task (Figure 1).

3 RISK MANAGEMENT FOR NPD

3.1 No risk: no NPD

Many NPD projects deviate from their initial target due to modifications or changes to customer needs as well as internal or external constraints. Other NPD projects may be simply stopped due to uncontrolled parameters and unidentified constraints arising from various processes within the NPD

project such as the product design process or the supply chain design (identification of suppliers and subcontractors for example). The consequence: no risk, no NPD. However, most project managers perceive risk management processes as extra work and expense. Thus, risk management processes are often expunged if a project schedule slips [20]. In a general way, main phases of risk management are: context analysis (1), risk identification (2), risk analysis (3), risk evaluation (4), risk treatment (5), monitoring and review (6) and communication and consulting (7).
NDP projects are interdisciplinary because they affect interdependencies between business processes and product and process reengineering. Therefore, to be effective, a risk assessment methodology (particularly the risk identification) has to consider several potential aspects (technology, market, financial, operational, organizational, and business) and link them to the project life cycle [21]. This ensures the selection of the most appropriate risk treatment strategy. Risk can be planned or unexpected, from external or internal origin, linked to market trends, eruption of new technologies, strategic or capitalistic decisions, etc.

3.2 Risk management process in NPD

We propose to provide to enterprise and project managers a model for risk management in innovative design, for assistance to the decision-making. The methodology is composed of three principal phases: the study at the strategic level (which must make it possible to identify strengths and weaknesses of the company), the study on the project level (relating to the project, once the scenario of innovating design adopted), and the study at the product level, relating to the phase of design itself. In each phase, a preliminary analysis of the risks is made in order to validate or not the choices carried out, which makes it possible to guide the decision makers in their decision-makings (Figure 2).

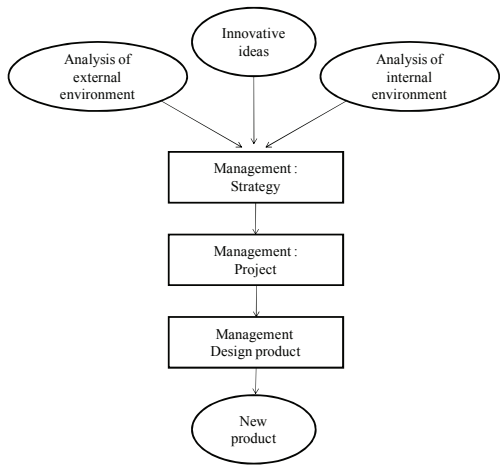

Figure 2. Risk management process for NPD

3.2.1: Strategic management

As a general rule, the strategic management process consists of three stages: strategy formulation, strategy implementation and strategy evaluation [22]. Strategy formulation determines where the enterprise is, where the enterprise wants to go, and how to get there: business positions management wants to stake out, financial and strategic outcomes to achieve. Analysis of external opportunities and threats as well as internal strengths and weaknesses of enterprises is important for strategy formulation and development. The purpose of the analysis of external opportunities and threats is to evaluate whether an enterprise can seize opportunities and avoid threats when facing an uncontrollable external environment, such as fluctuating prices, political destabilisation, social transition, change in rule of law, etc. The purpose of the analysis of internal strengths and weaknesses is to evaluate how an enterprise carries out its internal work, such as management, work efficiency, research and development, etc. [7]. Used in a business context, such identifications help the enterprise find a sustainable niche in the market: senior managers uncover opportunities that the enterprise is well

placed to take advantage of, and by understanding its weaknesses, it is possible to manage and eliminate threats that would otherwise catch it unawares. To sum up, strategic implementation involves understanding the nature of stakeholder expectations, identifying strategic options, and then evaluating and selecting strategic options. Strategy implementation carries out the allocation and the management of the resources affected by the project (financial, technical and human resources), then assigns responsibilities of specific tasks or processes to these resources. In other words, when the strategy has been analysed and selected, the strategy implementation has to translate it into organisational action. Finally, the strategy evaluation allows measuring the effectiveness of the organisational strategy. The strategic management process is dynamic and continuous. A change in one component can necessitate a change in the entire strategy. Consequently, the process must be repeated frequently in order to adapt the strategy to environmental changes. Hereafter is presented the strategic risk management process (Figure 3).

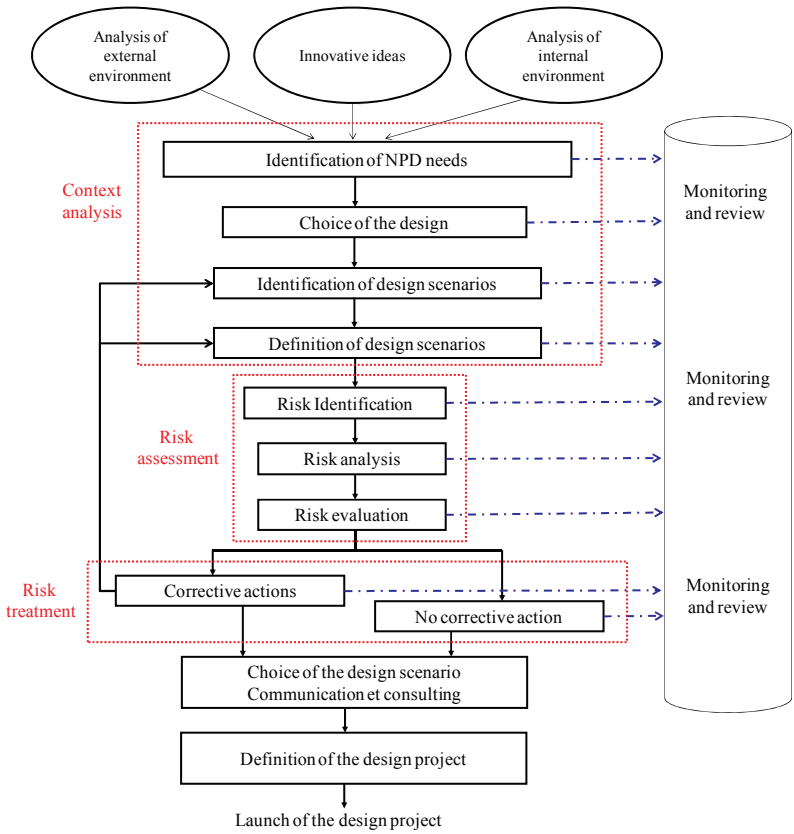

Figure 3. Strategic risk management process

3.2.2: Project management

Project risk management seeks to anticipate and address uncertainties that threaten the goals and timetables of a project. It is important to consider that risk is not only technical but it can come up from organisation, partnership problems, etc. Also, uncertainties may include questions of material and parts quality, delays in delivery of sufficient materials to meet project needs, budgetary and personnel changes, incomplete knowledge, etc. These risks lead rapidly to delays in delivery dates and budget overages that can severely undermine confidence in the project and in the project manager. While any project accepts a certain level of risk, regular and rigorous risk analysis and risk management techniques serve to defuse problems before they arise. We consider that a NPD project is a well-balanced-project when there is a compromise solution between technical contents (i.e.

technological and organizational aspects of the project), budget and time. Hereafter is the project risk management process (Figure 4).

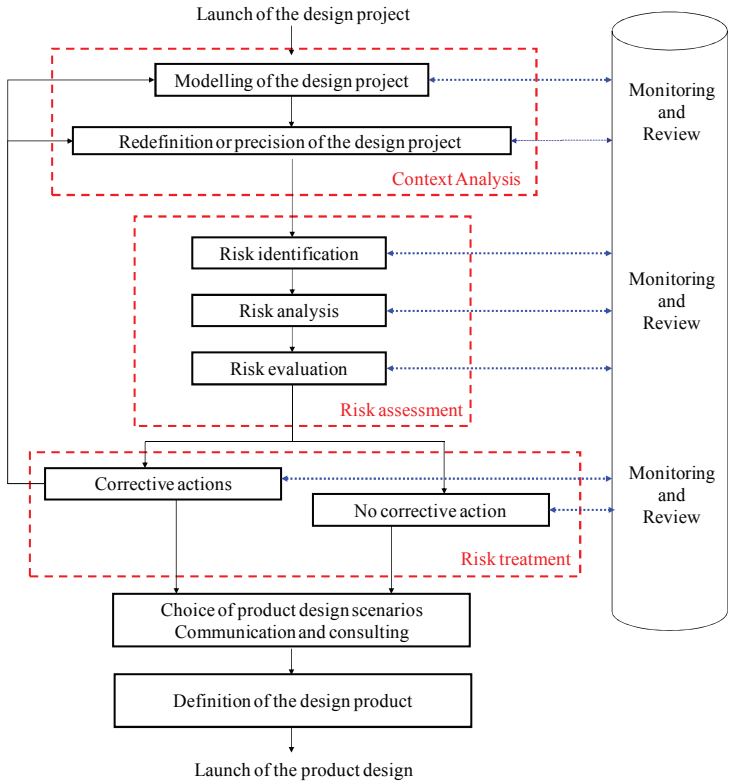

Figure 4. Project risk management process

3.2.3: Product design management

Risk inherent to product design is linked to the engineering design process. For a successful execution of NPD, all the PLM's stages must be taken into account, including product concept, detailed design, organization, production and so on [23]. Technological variations of these last years and the increasing competition led the companies to modify their products development activities. There are several categories of new products: completely new, repositioning, new product lines, core product revision, lines extension, etc. The paradigm of products platforms permits to classify different categories of products developments: a product platform is a grouping of individual products sharing a common technology. Also, a strategy of products platform allows to reduce the number of pieces and components, the costs relative to the design of buy-products and the investments necessary for new manufacturing processes. Hereafter is the design risk management process (Figure 5).

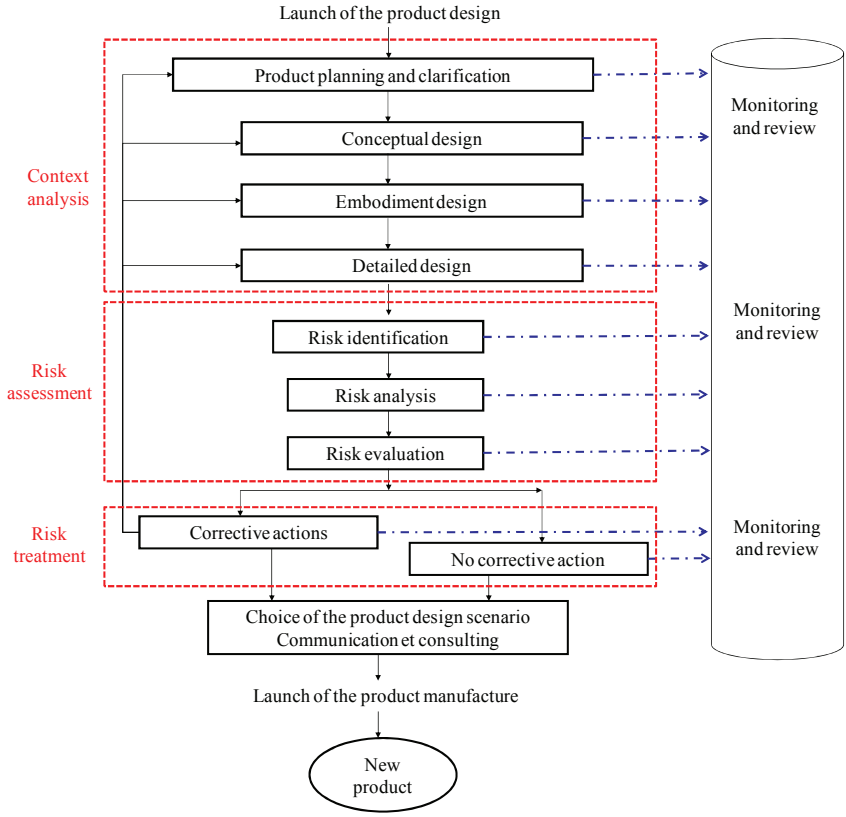

Figure 5. Product design risk management process

3.3 NPD project failures

Causes of failure have been widely researched and can vary considerably. Some causes will be external to the organization and outside its influence of control. Others will be internal and ultimately within the control of the organization. Internal causes of failure can be divided into causes associated with the cultural infrastructure and causes associated with the innovation process itself. Failure in the cultural infrastructure varies between organizations but the following are common across all organizations at some stage in their life cycle [24]: poor leadership, poor organization, poor communication, poor empowerment, poor knowledge Management. Common causes of failure (or risk factors) within the innovation process in most organizations can be distilled into five types: poor goal definition, poor alignment of actions to goals, poor participation in teams, poor monitoring of results, poor communication and access to information. We categorize NPD project failures as one of four levels, due to lot of risk factors (Figure 6):

- Process failure, when the project is not completed within time and budget, or when technical contents are insufficient. Indeed, innovation is effective only when the time required to innovate is shorter than the rate of change in the business environment;
- Expectation failure, when the project is completed but does not match customer's expectations. It is an external perspective of failure;
- Business failure, when the project is completed but does not match company's expectations. It is an internal perspective of failure;
- Collaboration failure, when the project is completed but partners' attitudes towards the company are negative.

Nevertheless, such categorizes NPD project failures don't take into account the creativity. This is ths objective of the next section.

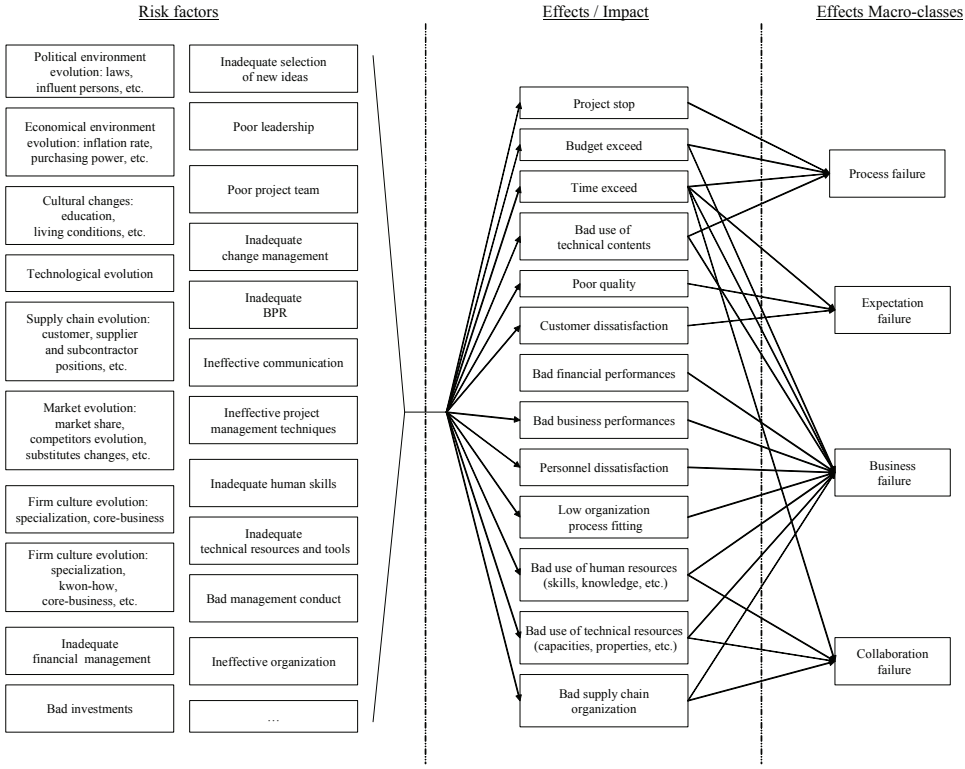

Figure 6. Risk factors and NPD project failures, adapted from [21]

4 RISK MANAGEMENT IN NPD PROJECTS: TAKING CREATIVITY INTO CONSIDERATION

Byrd said that "Innovation is the act of introducing something new" and explain that "the act of introducing" is akin to taking risk and "new" is about creativity. This leads on to what the authors call the innovation equation [2]:

$$\text{Innovation} = \text{Creativity} \times \text{Risk Taking}$$

According to these innovation equation, we propose to detail our risk management in NPD (or innovation) while considering jointly creativity and risk taking.

4.1 Risk taking

Risk taking refers to a decisional framework allowing to visualize the different risk criticalities. We consider that a risk is [25]:

- Slightly disturbing if it has no impact on the structure of the NPD project (case 1, Figure 7);
- Fairly disturbing if it acts upon the organic definition of the NPD project (case 2, Figure 7): capacities and / or competences of human and technical resources, legislatives constraints, etc.;
- Strongly disturbing if it requires strategic adjustments of the NPD project impacting its functional characteristics (case 3, Figure 7);
- Fatal if it makes the NPD project obsolete (case 4, Figure 7).

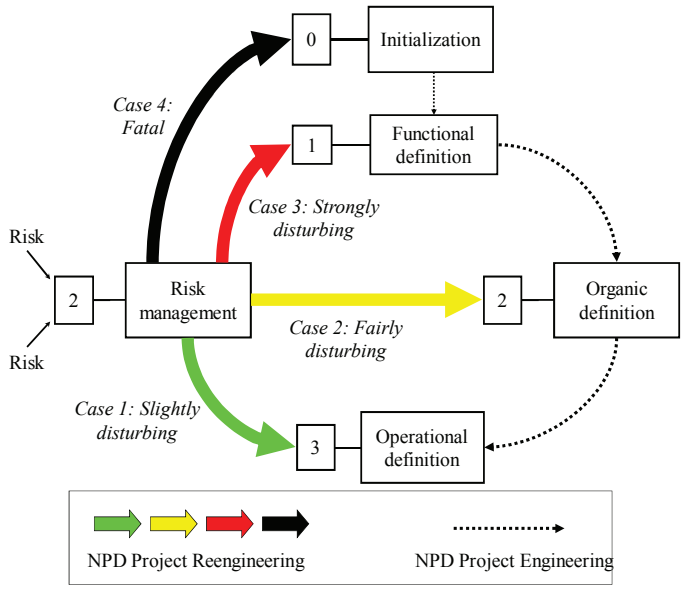

Figure 7. Disturbance classes of risk and impact on the NPD project

Then, risk criticality entitles to define actions to be carried out (Figure 9):

- A slightly risk belongs to the criticality class number 1 (C1), which includes a risk level acceptable in the present state.
- A fairly risk belongs to the criticality class number 2 (C2), which includes a risk level tolerable under regular control.
- A strongly risk belongs to the criticality class number 3 (C3), which includes a risk level tolerable with difficulty.
- A fatal risk belongs to the criticality class number 4 (C4), which includes an unacceptable risk level.

Criticality classes	Level of risk	Decision
C1 (case 1, Fig. 7)	Acceptable in the present state	No action or modification at the operational level. Follow-up, monitoring and review. Risk assessment.
C2 (case 2, Fig. 7)	Tolerable under regular control	Modification at the organic level. Follow-up, monitoring and review. Risk assessment.
C3 (case 3, Fig. 7)	Difficult to tolerate	Modification at the functional level. Follow-up, monitoring and review. Risk assessment.
C4 (case 4, Fig. 7)	Unacceptable	Change of strategy. Total reorganisation of the project.

Figure 8. Criticality scale and decisional framework

Obviously, such actions are dependent on the company's intention of doing risk management. Therefore, an effort combined with the actions of risk management can be defined according to a qualitative scale: for example, no action, vigilance or selective action, vigilance or periodic action, vigilance or continuous action, etc.

4.2 Creativity

Creativity success or failure is dependent on the creative individual and on the company's intention of developing creativity.

Criteria allowing to evaluate creative individual are for example: creative aptitude, know-how, competencies, motivation, availability, communication, etc. We decide to take into consideration a global approach of these criteria, and we adopt the following evaluation:

- 0 if the individual has no potential of creativity;
- 1 if the individual has a little potential of creativity;
- 2 if the individual has a significant potential of creativity;
- 3 if the individual has a very significant potential of creativity.

Criteria allowing to evaluate company's intention of developing creativity are for example: environment and working conditions, means, freedom of information, freedom of communication, freedom of action, etc. We decide to take into consideration a global approach of these criteria, and we adopt the following evaluation:

- 0 if the company is against the creativity;
- 1 if the company doesn't encourage employees to develop creativity;
- 2 if the company encourage employees to develop creativity;
- 3 if the company has strategic objectives including development of creativity.

By coupling these two points of view, we obtain the success or failure probabilities of creativity (Figure 9):

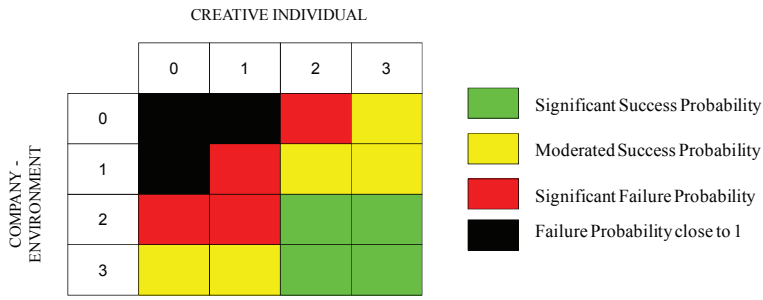

Figure 9. Success or failure probabilities of creativity

4.3 Synthesis

Thanks to the innovation equation Innovation = Creativity x Risk Taking, it is possible to analyze success or failure probabilities of a NPD project, taking into consideration the creativity. The methodology includes tasks of establishing the context, identifying, analyzing, evaluating, treating, monitoring and communicating risks resulting from design project dysfunctions for the risk taking aspect. It includes creative individual and company's intention of developing creativity for the creativity aspect. Combination of both aspects helps senior managers to determine success or failure probabilities of innovation (Figure 10). This work also constitutes a management tool allowing to improve strategic decision-making processes. Choices of senior managers are facilitated and they can find the best preventive actions to prevent a problem before it arises. Such actions will ensure the project (NPD) will meet the defined requirements.

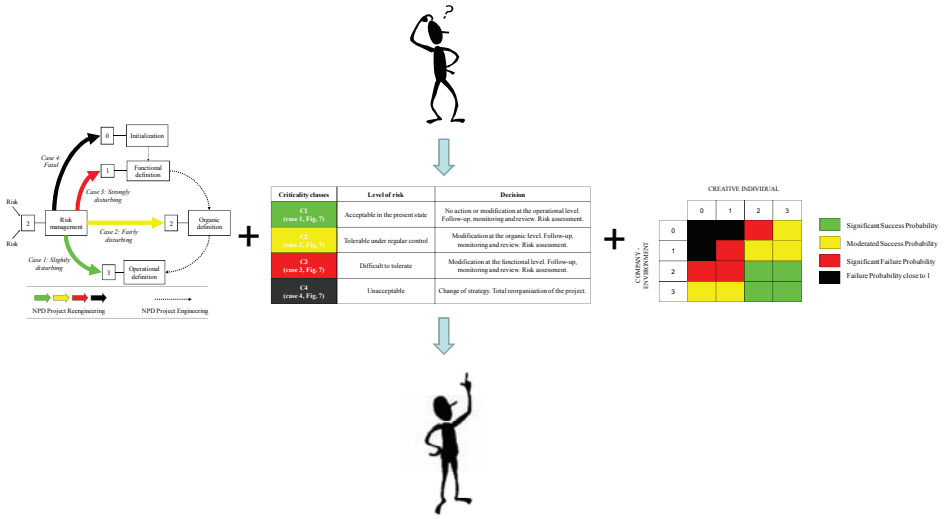

Figure 10. Synthesis

5 CONCLUSION

Considered as a solution for growth and competitiveness, New Product Development (NPD) is used by senior managers to create new sources of value, in strategic management. Nevertheless, it is necessary to manage NPD projects as efficiently as possible in order to deliver successful products on time and to budget, and assess the numerous risks in NPD processes. In this paper, we have presented a preliminary analyze of the NPD process in order to understand when and how potential risk factors can be identified. Subsequently, we have categorized four main NPD project failures. In addition, since innovation is a function of creativity, NPD projects success or failure is dependent on creativity. Consequently, this paper has established a risk management procedure for NPD projects, including risk due to creativity. Such a procedure facilitates decision-makings of senior managers and also improves global performances of companies.

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Contact: Severine Sperandio
University of Bordeaux
IMS - LAPS
351, cours de la liberation
33405 TALENCE cedex
FRANCE
Tel: +33 (0)5 40 00 65 32
Fax: +33 (0)5 40 00 66 44
E-mail Address : severine.sperandio@u-bordeaux1.fr
http://www.ims-bordeaux.eu