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HOW TO EVALUATE THE NPD PROCESS AGILITY IN AN INTENSIVE INNOVATION CONTEXT?

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ABSTRACT

In this paper, we focus on the product development of a complex system in a context of intensive innovation. Manufacturers need to produce a permanent stream of innovations, to meet the (ever constant) demand of evolutionary customer requirements, technologies and social factors. An innovation leads to some changes regarding the product value, functions and structure, which can modify the product dominant design and the product architecture. We assume that these modifications in early stages of the innovation process can create some periods of instability at the NPD (New Product Development) process level. Indeed, innovation displaces the interfaces and inter-relations between sub-systems of the complex product and requires new skills and knowledge to master the product and process development.
The challenge of intensive innovation repeatedly alternates between periods of instability (learning, new skills acquisition, immature information management, new roles definitions) and more stable periods (routines, reuse of previous work, well defined roles…).
In this paper, we use the concept of agility to qualify a NPD process ability to face these repeated periods of instability in a context of intensive innovation.
After the identification of the key dimensions of the concept of agility, we argue that this production ability could also be useful at the product development level, to face repeated periods of change due to intensive innovation. Then, we give our definition of an agile NPD process, and our hypothesis regarding its main dimensions and leverages. Finally, through a case study, we illustrate our research hypothesis with real examples, and identify in an agility matrix some key engineering practices to assess in order to qualify the degree of agility of a NPD process.

Keywords: product development, agility, maturity, performance assessment

1 INTRODUCTION

A few years ago, innovation mainly concerned specific sectors and product types. Nowadays, all manufacturers have to innovate, to survive in their environment, and they are looking for ways to improve their innovation abilities. Manufacturers need to face frequent changes regarding customers' requirements and to launch a continuous flow of innovation, to renew the product identity. The products are renewed faster than in the past and manufacturers need to cope with the instability of the product identity, notably by promoting cooperation within their enterprise. We identify the notion of agility as one of the main drivers of the innovation process, to respond to various changes created by the introduction of a permanent stream of innovation.
In this paper, we focus on the NPD phases of the innovation process represented on the Figure 1. The NPD process aims at developing the innovative product concept selected during the FFE (Fuzzy Front End) phase, by respecting the cost, time and quality constraints.

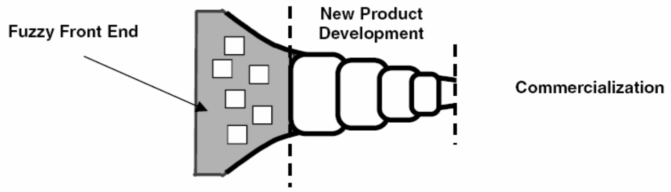

Figure 1 : The innovation process [1]

The NPD is characterized by an alternation of formal gate reviews, and some stages of iterations and information exchanges, to make decisions regarding the product and the process.
After the identification of the key topics of the concept of agility, we argue that this production ability could also be useful at the product development level, to face repeated periods of change due to intensive innovation. Then, we give our definition of an agile NPD process, and our hypothesis regarding its main dimensions and leverages. Finally, through a case study, we illustrate our research hypothesis with real examples, and identify in an agility matrix some key engineering practices to assess in order to qualify the degree of agility of a NPD process.

2 THE ESSENTIALNESS OF AGILITY

This concept appeared in the mid 90's [2]. Agility is said to be the new paradigm of the 21st century for manufacturing companies, and is defined as : "*The ability of an organization to thrive in the competitive environment of continuous and unanticipated change and to respond quickly to rapidly changing markets driven by customer based valuing of products and services*." [3]. Most of the authors refer to agility more in the context of manufacturing process than design process and are from operation management sciences.
In the Table 1, we analyze the literature through 4 topics developed by the authors. According to us, these topics are relevant in order to discuss agility in NPD whenever the features proposed by the authors are more focused on production process. Based on these 4 topics, the next parts will discuss the identification of relevant features to perform agility in NPD.

Topics	Key features in manufacturing agility…
Nature of changes	Market, competition criteria, customer requirements, technology, social factors [4]
Agility providers	Core competence management, Virtual enterprise formation, Capability for reconfiguration , Knowledge-driven enterprise [5] Technology [6] [4]), management[6], organization[4], workforce [6], people[4] innovation [4] extended enterprise (customer integrated multidisciplinary teams, supply chain partners, flexible manufacturing, computer-integrated information systems, and modular production facilities [7]
Agility capabilities	Responsiveness, Competency, Flexibility, Quickness [4]
Agility indicators	Cost, Time, Robustness, Scope [8]

Table 1: The main topics and features of agile manufacturing

Agility is required to face the competitive environment characterized by a high level of uncertainty and constant change. Changes come from different sources or natures: customer requests, new competition criteria in the market, new supporting technology and social factors [4]. All these changes impact on the production system, which must be able to "*shift quickly (speed and responsiveness) among product models or between product lines (flexibility), ideally in real-time response to customer demand (customers needs and wants"[9]* in a timely manner and cost effective way. One of the main sources of change is from customers. Customers are more demanding than in the past, as they want highly customized, relatively inexpensive and fast delivered products [6]. This demand for customization impacts on the production main paradigm. Mass production has been slowly replaced by mass-customization, aiming at "*producing goods and services to meet individual customer's needs with near mass production efficiency"[10]*

The ability to perceive the nature of change is one of the cognitive ability of agility. Manufacturers then need to make some decisions to face this change, by activating **agility providers** and employing **agility capabilities**. The effectiveness of their use can be assessed by **agility indicators**.
The agility providers are that which can be mobilized to be agile, such as technology, organization, extended enterprise or information system. However, mobilizing it is not enough to be agile, manufacturers also need to develop agility capabilities[4]. Some are specific to time-based competition such as responsiveness (identify changes and respond fast to them), or quickness ("*carry out tasks and operations in the shortest possible time"),* whereas others concern more the *competency, to "mobilize the extensive set of abilities to achieve goals of the company" or the flexibility, to switch between different product or objectives without changing the facilities[4]*. To sum up the concepts linked with agility, one can remember that "*agility is the successful exploration of competitive bases (speed, flexibility, innovation pro-activity, quality and profitability) through the integration of reconfigurable resources and best practices in a knowledge-rich environment to provide customer-driven products and services in a fast changing market environment*" [5].
Finally, the agility of the manufacturers can be assessed according to certain agility indicators, such as cost, time, robustness and scope[8]. Hence, the required abilities must be activated in a cost effective and timely manner, to produce a robust production system that is able to absorb different scopes of change. According to Yusuf [5], the more a manufacturer is agile, the more the following dimensions are optimized: Core competence management, Virtual enterprise formation, Capability for reconfiguration , and Knowledge-driven enterprise.

In the next part, the context of intensive innovation is described, to underline the new challenge of carry-over and innovation faced by manufacturers. This description aims at underlining that agility abilities are also necessary in product development phases.

3 AGILITY: TO FACE CHANGES DURING PRODUCT DEVELOPMENT

In this part, we define the context of intensive innovation, as well as the need to reuse and learn new knowledge and skills during the NPD process, to face the product dominant design changes.
Besides mass-customization, manufacturers need to face a new modification of the competitive environments : the shift toward *intensive innovation [11]*. Hence, manufacturers need to develop a constant flow of innovative new products, without impacting on the "time to market", to face very evolutionary customer requirements and reduced product lifetime. Intensive innovation characterizes the "*necessity for companies to organize a programmed and systematic effort to generate innovations using all possible product or service values that can be improved (technology, usage, logistics, symbols, societal values…)*"[12]. *Intensive innovation* implies rapid and frequent change in dominant design. Murmann and al [13] realized a very exhaustive state of the art regarding the concept of dominant design, that they define as "*nested hierarchies of design spaces*". The dominant design which is "*characterized both by a set of core design concepts embodied in components that correspond to the major functions performed by the product and by a product architecture that defined the ways in which these components are integrated*"[14]. It can be studied at the same levels as radical innovation. Radical innovations have been defined either in comparison of existing knowledge or in terms of their consequence i.e. the increased performance they make possible [13]. Radical innovation can occur at the same level as the modifications of the dominant design : *individual component, individual subsystem, or a higher level of aggregation*[13] such as the whole product architecture for example.
A modification in product architecture and configuration impacts strongly on the industrial organization, as a dominant design is "*a selected combinations of design choices and related competencies that allow for a long term and large scope of product development and improvement*"[12]. Hence, we assume that the ability to absorb repeated innovations at the level of NPD process implies the ability to manage repeated modifications of the product dominant design.
To summarize our idea, we represent the main challenge of intensive innovation of the NPD process in the *Figure 2*: Absorb repeated periods of instability. That is, to alternate between periods of instability (learning, new skills acquisition, immature information management, new roles definitions) and more stable periods (routines, reuse of previous work, well defined roles…). We assume that a radical innovation creates a higher level of instability than an incremental innovation, as it introduces more

changes and requires as a consequence a longer period of transition to face these changes. Moreover, radical innovation might be followed by several incremental innovations, to increase the product robustness and take into account feedback from the product users. Innovation is both a consequence of changes and the cause of changes within the NPD process.
Indeed, innovation is the response of manufacturers to take into account some perceived changes such as customer requirement (by integrating new value in the product), competition criteria (an evolution of a dominant design), technological change (leading to the integration of a new technology in the product), or social factors (a need to use less non-renewable energy). Innovation is also a cause of change at the NPD process, as it modifies the product dominant design and impacts on the NPD process organization, information flow and human resources.

In this section we have identified the new *nature of change* that companies have to face in an intensive innovation context.
We already have some hypothesis regarding the key challenges to face the periods of transition, such as new skills and knowledge learning to master the product architecture, collaboration to manage the requirements and product interface evolution, as well as uncertainty management. We develop these agility providers in the fourth section of the article.

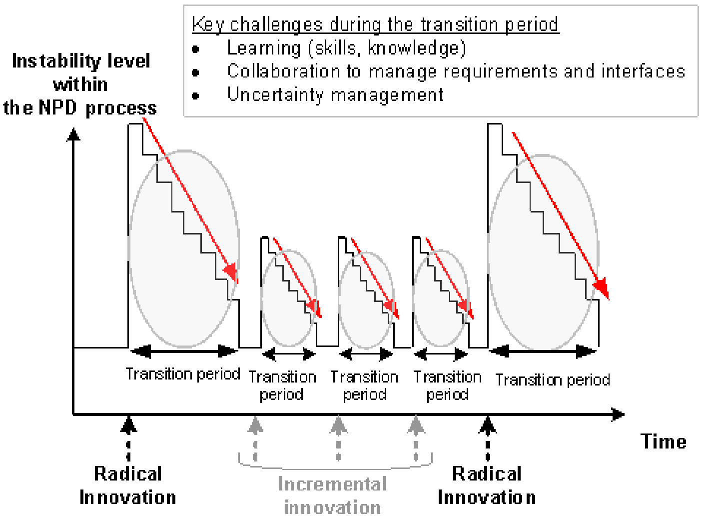

Figure 2: The challenge of intensive innovation: Absorb repeated periods of instability at the NPD process level

4 NPD PROCESS AGILITY

Intensive innovation creates some periods of instability at the NPD process, characterized by uncertainty and a need of learning, to acquire the required skills and knowledge to manage the product development. Taking into account the context of change induced by intensive innovation, we assume that agility is particularly relevant at the NPD level. We then suggest the following definition of agility in NPD, which can be used as a guideline of our research work.

The NPD process agility is:
"*The ability to face repeated periods of instability due to some modifications of the product dominant design:*
- *By anticipating the impact of such a change*
- *By developing the innovative product in a cost effective and responsive manner i.e. without negatively impacting NPD on cost, quality and time.*

In the following sections, we suggest the main dimensions required by an agile NPD. These dimensions are crossed to the leverages of action for managers of NPD, in an agility analysis matrix.

4.1 The main dimensions of an agile NPD process

The main challenge during the NPD process is to face periods of instability, caused by major changes to the product architecture, sub-system and interfaces levels. Based on this observation, we deduce the main dimensions that an agile NPD process should master:

- Product architecture
- Uncertainty
- Knowledge and skills

Dimension 1: The mastery of the product architecture

The dominant design is closely related to the product architecture. Ulrich and Eppinger [15] define architecture as the scheme where functional requirements are organized into subsystems and physical components. Then, evolution of functions or components of solution deeply impacts the product architecture. Architecture can be seen as a technical problem related with the skills of the design team, but it is important to notice that the organization of the design, division of work and the supply chain are generally optimized in the context of a specific product architecture [16]. The cross learning between design teams allows to build routines that facilitate coordination. Then many implicit knowledge had been built at the interfaces of teams and are hard to move when architecture changes. Thus we claim that the mastery of product architecture is a key issue for agility in NPD. Without deeply investigating here this point some ways can be suggested to improve the mastery of architecture according to the literature. It got to have along with it a deep understanding and knowledge about the product and the interrelations between sub-systems (to quickly identify the impact of the change). We agree with Thomke when he suggests the use a "design for flexibility" approach during innovation projects, to have flexibility as an explicit objective during earlier phases of development by "*carefully selecting the boundaries between system components and design tasks to minimize total system interdependencies*". From then on, modular architecture [17, 18], can certainly be a way to explore. Expecting that the decrease of interdependencies between systems allows localizing the impacts of change and that the standardization of the interfaces facilitates their mastery. Taking into account that changes can come from requirements or from subsystems, two topics have also to be addressed in the design process to master architecture: requirements management and change management. Thomke [17] argues that agility also requires " *rapid decisions on critical changes, and the ability to run rapid, test-driven design iterations*".
The changes in dominant design imply the evolution of the product architecture that necessitates organizational change and show limits of established knowledge in sub-systems interrelation. These elements increase the uncertainty to be mastered.

Dimension 2: The mastery of uncertainty

The NPD process is usually studied through the concept of phases, stage and gate, but this view does not underline the high level of concurrent activities. Concurrent Engineering organization implies the development of coordination strategies between activities [19]. The overlapping of activities had changed the nature of information to preliminary information (i.e immature information)[20].
We assume that a more interesting way is to study the NPD process through the information flow perspective. The early phases of product development are usually characterized by a high level of uncertainty, mainly due to the lack of information regarding the product and production process. The more the information is available, the less the liberty scope for the manufacturers, as previous design choice reduces the number of solutions. The management of the uncertainty and the quality of information is then crucial. When developing an innovative product, the uncertainty is increased, as the nature of exchanged information on the product is less mature. The use and integration of new technologies to the product, as well as the move of certain sub-system interfaces require to manipulate immature information (low precision, instability, incompleteness….) [21], which are still in an iteration stage and are not validated. Although many approaches of information management tend to

avoid the uncertainty, we argue that in innovative design actors have to manage it. But currently information systems are not very well adapted to manage heterogeneous maturity of information [22]. Designers mainly publish pre-validated information just before milestones when they could diffuse preliminary information sooner. This point deals with risk management [23]. According to McManus and Hastings [24], which provide a framework for understanding uncertainty in complex systems, uncertainties may "*provide opportunities as well as risk"*. As the convergence towards a validated solution might be long, we suggest managing the uncertainty maintained during the NPD process, with a better structuring of exchanged immature information. Being able to take advantage of uncertainty might lead to very interesting outcomes in terms of product attributes such as "*reliability, robustness, versatility, flexibility, evolvability, and interoperability*"[24]. We assume that one way to develop NPD process agility is to allow the management of immature information.

Dimension 3: the mastery of knowledge and skills

We have seen that intensive innovation is linked with the ability to introduce "significant rupture in products, markets, technologies identity"[25]. These ruptures impact on the product dominant design, which can be managed thanks to new knowledge and skills. The C-K theory ([26, 27]p. 281) illustrates the goal of innovative design which is to explore new values and concepts (C), and using or creating in the same time knowledge (K) necessary to validate the concepts. The challenge is to reuse a maximum of current knowledge (carry-over) and learn what is required, to be able to revise the objects identity to develop. As a consequence, development teams need to develop and accumulate new knowledge, and learning in disciplines related to NPD projects.

The ways to create and manage the knowledge can be either internal or external.

From internal point of view, the *multi-projects management* approach is a way to manage interaction within a set of projects, to know where the skilled resources are and reuse at the maximum the previous work. According to Kidd, human resources management is another way: "*development of a well trained and motivated workforce, with the right set of skills, expertise and knowledge, as an essential element of their strategies"(Kidd (1994) [5]).* Finally, design teams have to develop their ability to integrate new knowledge and know how from various disciplines. Collaborative engineering skills are then required to perform this cross learning processes.

From the external point of view, NPD should be able to mobilize when necessary the required skilled resources (partners, suppliers, clients…). It implies to rely on the network of the extended enterprise, and be able to select and integrate right partners on right time. The company has to develop a specific know how to manage these inter-firm relations. [28]

These processes of learning and creation of knowledge require a long term strategic vision, despite of the short term and dynamic rhythm of innovation.

Hence, we assume that the three key requirements to be fulfilled by an agile NPD process, are product architecture, uncertainty, and knowledge and skills mastery in a context of extended enterprise. We identify in the next section the main leverages to activate, in order to face with success these periods of instability during the NPD process and to be agile.

4.2 The NPD agility analysis matrix

NPD are mainly linked with some problematic of breakdown and integration of the product, requiring closed collaboration between actors of different disciplines, project team and sometimes of different enterprises (in case of co-development with suppliers). It requires managing coordination, cooperation as well as communication within the enterprise. In the literature, some agility leverages are identified, to face changes and be agile, such as "*technology, management and workforce into a coordinated interdependent system*" [6]. In their conceptual model of agility, Sharifi and Zhang suggest that agility providers are supposed to be brought from four major areas of the manufacturing environment : "*organization, people, technology, and innovation*" [4]. They also underline the powerful support of "*information system/technology*" [4] for agility providers.

Taking into account our hypothesis regarding the dimensions of an agile NPD process, as well as the case study and the literature review, we identify the following leverages of agility at the NPD process leve :

- **Human resources** represent the actors of the NPD process, as well as their skills, knowledge and know-how.
- **Information technology** corresponds to the information systems tools, to represent and manage the product information.
- **Process Organization** relates to the enterprise NPD process organization in the context of extended enterprise, in terms of work breakdown structure, namely the role and responsibilities allocated to the different actors.

Thus we propose the following matrix, to position the different kinds of problems encountered during a period of instability, when developing an innovative and complex system. This matrix can serve as an analysis framework when studying a real case example.

	Human resources	Information technology	Organization
The mastery of the product architecture			
The mastery of uncertainty			
Knowledge driven			

Table 2. The analysis matrix of NPD process agility

5 CASE STUDY ANALYSIS

5.1 Case study description

In order to illustrate this framework of analysis, we investigate a case study of a complex and innovative product development. This case emphasizes some typical problems raised by a modification of the product dominant design. The case is based on a consulting experience regarding a mission realized for a complex system manufacturer. For confidential reasons, we are neither allowed to use the name of the company, nor the kind of product developed. The mission's goal was to accompany this manufacturer in the development of a complex product, which highly perturbs the existing organization, as it is very different from systems developed in the past and introduces a lot of changes. Among the main changes, it functions with new energy sources, it integrates new technologies not well mastered, and modifies the product architecture.
In the following, we describe this case, to identify the main problems raised at the NPD process level, when developing a very innovative concept with a breakthrough in the product dominant design.

Problem n°1: No internal references to guide the new product development
The problem raised from start is the lack of references, from which to develop the new product in comparison with previous work. Indeed, for the previous development, the manufacturer used to rely on their experience, by identifying the delta variation to be realized comparing to the previous work and make some incremental changes. But in the case study we describe, the problem is different, as the manufacturer has no previous reference to develop the innovative system. This means to say that the company has never developed this product before. As a consequence, they need to observe the product of competitors through some economic intelligence, and analysis of competitors, and try to imitate them.

The question is how the learning regarding the new product to develop should be promoted, in terms of technology, interface management, interrelation between subsystems and validation of the whole system?

Problem n°2: The mastery of the product architecture

The manufacturer chose to develop this new product in order to face different changes including: customer requirements (less energy consumption, reduction of the product cycle cost), market change (competitors begin to use this innovative product in other sectors), social factors (willing to have an eco-friendly product and consuming less non-renewable energy). The new product to develop embodies several changes, in terms of product architecture, functions and sub-systems, as well as new interdependencies between functions and sub-systems.
Due to the complexity of the system, one of the challenges is to have several views of the product to manage the consistency and traceability between requirements, and the integration of the global view of the product, according to the Functional Breakdown Structure (FBS), System Breakdown Structure (SBS), Requirement Breakdown Structure (RBS). As the work breakdown structure (WBS) is closely linked with the system breakdown structure (SBS), a modification of the SBS impacts strongly on the WBS.

Several questions and problems are raised:

- How should the work be organized while taking into account the high dependency levels between functions, systems? Which roles and responsibilities should be filled by each actor?
- How should the whole product development be overseen, to guaranty architecture information mastery and to be able to verify and validate the product at the function and system levels, for an effective multi-system integration?
- How should the resources and resources sharing between multi-projects be supervised so as not to impact negatively on deliverable quality, cost and delivery?

We observed a lack of structure of information flow. The information exchanges are incomplete and not well formalized. For example, the collaboration between designers and engineers from different disciplines is realized through emails, some Microsoft Excel tables, and long meetings. A great deal of time and money are lost, because no formal record is kept of the information exchanges. There is a problem regarding the status of the exchanged information, as well as the coordination and formalization of the information exchanged between different actors.

The question is how the information flow between actors should be structured, in order that each actor has access to relevant information, with the right degree of maturity and quality, at the right time, to be able to work on his/her task and make effective decisions?

Problem n°3: Interface management

The interface problem is found at different levels. It first refers to the technical and functional interface of the product, which requires the mobilization of the multidisciplinary team, in order to ensure the multi-system integration and mastering of their interfaces.
At the technical and functional level of interface, one of the key issues is the management of the interface between sub-systems, which are strongly interconnected with different kinds of interfaces:

- Energy flow (electromagnetic, thermic…)
- Information flow (octets exchanges between system)
- Physical interface (packaging, system).

Hence, for each interface, the product development requires the mobilization of actors from different disciplines. One of the key issues is to represent the product information necessary for multidisciplinary teams, with a multi-view representation of the product. Thereby enabling the engineers and designers to exchange on their discipline constraints, make trade-offs and solve their problems. A multi-view representation allows to communicate and cooperate, even though the actors from different disciplines are not speaking the same "language", with notably differences for certain key words.
The development of this new product also strongly modifies the disciplines culture. Indeed, previously the dominant discipline culture was mechanics. Hence, the control culture, mainly based on electronic boarded system becomes more critical, as the sub-systems communicate more and more between each

other. Moreover, with the new coming "mechatronic" technologies, the need for cross-culture becomes more and more crucial.

The question is how the change management should be ensured, to change the dominant mindset (more functional, more multi-systems integration) and to ensure the knowledge evolution (lack of knowledge and skills)?

5.2 Analysis of the case through the matrix

In order to face this dominant design evolution, the studied company develops new practices using different leverages. We identify the main engineering practices linked with the NPD process agility in *Table 3*. These engineering practices represent some elements of response to use in the studied NPD in order to face the challenge of this innovative product.

- **"Product architecture dimension" matrix row**: the human resources should be able to integrate constraints while taking into account the interdependencies of the interfaces. To support the need to have a multi-view representation of the product, information technology should provide some ways to represent the different engineering requirements, as well as the different views associated with it. At the organization level, we think that the consistency of the product architecture can be optimized through better coordination and the definition of specific roles such as :
    - **The product architect**: Masters the global product layout information (works in close partnership with marketing, to keep in mind the customer requirements), responsible for all the function and the global product architecture (system layout).
    - **The system integrator***: Ensures global system (sub-system) integration, and supports the product architect and works in close partnership with the function responsible.
    - **The function responsible***: Ensures that the function is well developed within different systems linked with it.
    - **Sub-System responsible and engineers**: in charge of the development of a specific sub-system.

**Multi-physics and multi-disciplinary skills or interfaces competencies are critical for the System integrator and the function responsible: to be able to make the link between for example disciplines such as mechanics and control.*

	Human resources	Information technology	Organization
The mastery of the product architecture	• Product view (global and sub-system interdependencies)	• Multi-view • Requirement management	• Coordination • Architect role
The mastery of uncertainty	• Taking advantage of uncertainty	• Information Maturity model	• Cooperation • Collaborative agreement
The mastery of knowledge and skills	• Ability to learn and collaborate	• Knowledge Management and collaborative engineering	• Learning and dynamic organization • On time supplier involvement

Table 3: Main engineering practices linked with NPD process agility

- **“Uncertainty mastery’ matrix row**: Human resources should have a mindset aiming at taking advantage of uncertainty, and to see it as an opportunity instead of a risk. But to do so, information technology should support this risk taking, by providing a way to give more meta-information on the information status, such as the completeness, stability, confidence degree, as well as maturity level. As uncertainty implies to have a probabilistic approach and suggest hypothesis, a key challenge at the organization level is the rapid formation of teams that can work together to solve particular raised problems. The consulting company recommends using some “collaborative agreements”,that defines the nature of collaboration between many disciplines, in terms of exchanged disciplines objects and their maturity, exchange protocols, milestones to deliver the object, dependencies between objects. It allows for better formalization and collaboration and avoids delay due to bottleneck in information exchange for example.
- **“Knowledge mastery” matrix row:** The NPD process needs for designers being able to learn new know how and to collaborate. Information technology should allow the capitalization, and reuse of knowledge. Such technology should also allow the representation of different kinds of knowledge: specific to some disciplines or knowledge interface. It is important to create knowledge dynamic, to be able to deliver knowledge with responsiveness. It implies to know within the organization the knowledge “owners” of such a specific knowledge. In case of lack of this knowledge, it is necessary either to train people within the firm, or select and integrate new partners mastering this knowledge.

CONCLUSION AND PERSPECTIVES

The challenge of intensive innovation is to face repeated periods of instability, by anticipating the change of dominant design and respond to it without impacting on NPD process time, cost and quality constraints. As a consequence, we identified agility as a key ability needed during product development phases, to cope with alternation of stable and more instable periods.

Adopting a performance assessment perspective, we suggested key dimensions of an agile NPD process, as well as agility leverages, such as human resources, information technology and organization, which results in the development of a matrix framework.

Through the analysis of a case study, we underlined the impact of dominant design changes, in terms of evolution of boundaries and scope evolution of skills and knowledge associated with the product. We identified some key practices to face these changes. The case study allowed to illustrate the different dimensions of the matrix.

The next step of this research is to carry out a series of interviews with complex system manufacturers, to identify main problems encountered when developing innovative product and the main practices to increase agility in NPD. Then, we would propose indicators in order to assess the agility maturity level of a NPD process. Our long term goal is to create a matrix to use during a consulting mission. This matrix should identify key practices areas to assess, and a definition of maturity levels. When applying this assessment tool, a consultant could identify the key engineering areas requiring improvement, thereby providing a foundation for recommendations in terms of improvement axis and roadmap.

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