Building innovation capabilities.
The development of design-oriented organizations.

Armand Hatchuel, Benoît Weil, P. Le Masson
Ecole des Mines de Paris, armand.hatchuel@cgs.ensmp.fr

Second draft september 2003 [1]

Chapter for the book :

Innovation, learning and macro institutional change: Patterns of knowledge changes

J. T. Hage, Ed.

Abstract

Innovation received an important interest in the literature. Yet, research still seeks a better understanding of how to develop innovation capabilities in organizations. In this paper, we present an approach coming from deep qualitative studies in a few companies showing a rare capability to innovate repeatedly during several decades. In the paper we use two case studies to illustrate how these companies stimulate innovative design behavior in a sustainable way. They use existing knowledge to create new products and existing products to create new knowledge. They generate and combine lineages of products and lineages of knowledge. This behavior cannot be fully captured through the classic structural variables of organization theory. In addition, we need a framework coming from recent perspectives on design theory which define « design » as the dual generation of concepts (innovations) and knowledge (competencies). This framework offers an operational view on innovation. It emphasizes the notion of « design strategies » as guidelines both for knowledge creation and for structural dynamics. Classic notions like work division , functional structure, organic structures have to be revisited as they are not good descriptors of collective design processes. A new contingency approach of organizations is explored which predicts the emergence of « Design-oriented organizations » (DO2) as a new organizational model that fits correctly with our case studies. DO2 do not obey to a functional, matrix or network structure but to a design based developmental logic. Thus, the diffusion of successful and sustainable DO2 is a major institutional issue for contemporary global competition.

***

[1] This draft has benefited from the remarks of Jerry Hage on a first short version of this paper.

Introduction : a design-based approach of innovation

1. Intensive innovation and contemporary competition. In this paper we develop the idea that many of the weaknesses of contemporary organization theory about innovation come from the non-recognition of Design theory as a necessary complementary entry to understand what means an **innovation capability** in organizations. This is a survival issue in contemporary societies. Without insights from Design theory, the organizational and cognitive consequences *of an innovation-based competition in modern economies* are not fully perceived or they are reduced to mere externalisation and globalization. Some well known signs of this type of competition are the following :

- The proportion of design work and personnel (R, D, marketing, style, prototyping…) has increased permanently in the last decades (This can be seen from OECD data). This is also directly observable in the main high tech companies in aeronautics, car industry, telecom and computer…
- Project management, knowledge management, vision or value creation are dominant management catchwords.
- Research departments are more oriented to fast product development (Hatchuel, Le Masson and Weil 2001; Lenfle 2001).
- Innovation oriented alliances have exploded in the last decades (Hagedoorn 2001)

As innovation is not a new phenomena in business or industrial history, we have proposed to characterize the contemporary innovation regime by the notion of « intensive innovation » (Hatchuel, Le Masson and Weil 2002). We mean by this 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…). Such deeds existed in business History even in the early industrial revolution. However, it never concerned so important expenditures and so many high skilled people.

2. **Innovation and the limits of organization theory** : Classical organizational theory was mainly developed in companies when the scope and influence of innovation activities were less important than in contemporary ones. This is also valid for Design activities. The classic Mintzberg's synthesis (Mintzberg 1981) surveyed research before 1975. A few years before « Toyotism », he described the car industry as not very innovative! Design activities were viewed as a « standardization function » but not as an innovative capability. The organizational determinants of innovation commonly studied in the literature have been surveyed (Damanpour 1991). They are : specialization, functional differentiation, professionalism, formalization, centralization, managerial attitude towards change, managerial tenure and technical knowledge resources. All these variables belong to the theory of bureaucracy. Are these descriptors adapted to companies where R&D has become central (Hage 1999) ? More generally can we describe design activity (conceptual research, engineering, style, architecture,..) within such framework ? The development of project based organizations (Lundin and Midler 1998) has been also an important management trend during the last decade. Yet, it is not easily interpreted in the language of organizational structure. Projects create both centralization and decentralization, flexibility and formalization, managerial tenure at the project level and managerial complexity at the organization level (Lundin and Midler 1998).

Projects *creates several structures, they also shape a design logic.* A project is not a known sequence of actions that have to be performed according to standards. It is an assigned mission which can combine large autonomy and tight specifications and requirements. According to classic dictionaries the word « project » belongs to the legacy of Architecture. Hence the development of project-based organizations can be interpreted as *a sign* of the increasing necessity in contemporary competition to expand the organizational language with words coming from Design theory or practice (we will come back later to this point).

3. A research program : combining Design theory and organization theory. These preliminary remarks are some first material in favor of the central propositions of this paper : i) *we can better understand the development of capabilities to innovate If we consider the dynamics of design activities as a the regulating process of innovative companies*. ii) Design dynamics cannot be described neither within a « structure-conduct performance » paradigm, nor within an organizational learning perspective. Design is a specific form of reasoning or a model of thought (Simon 1969), and a specific collective work that cannot be described as a classic division of work. The innovation capabilities of an organization are thus deeply embedded in the design competencies of a company. And the generation of these competencies (sometimes over a decade) is tightly linked to history of the innovations produced by this company.

In the first section of this paper we briefly survey the main findings of the literature concerning innovation and insist on the important and often implicit influence of design themes. **In the second section**, we discuss two case studies of companies that has been repeatedly innovative during at least three decades. This cases are part of a larger empirical investigation that cannot be described here. However, they will provide illustrations of the design dynamics underlying a powerful capability to innovate. **In the third section**, we introduce some elements of Design theory using a framework (proposed by (Hatchuel 1996), and (Hatchuel and Weil 2002; Hatchuel and Weil 2003)) which gives a unified and operational perspective on Design. Design is defined as a collective activity aiming to «expand » « concepts» and « knowledge » to reach temporary design solutions (products, services). **In the last section,** we use this framework to revisit classic organizations and we discuss what we call Design-oriented organizations (DO2) which are adapted to repeated innovation.

Section 1 : Innovation as an organizational enigma.

1.1. Organic structure vs. organic behavior : revisiting a classic : Organization Research about innovation was initially developed through the structure-conduct-performance paradigm. Authors tried to find the type of structure or structural variables that favor and support innovation. The «organic structure » was early suggested as the most adapted to innovation by Burns and stalker (Burns and Stalker 1961). It has been repeatedly confirmed in the literature (Damanpour 1991). However, this result is a paradoxical one. The notion of « organic » structure is rather fuzzy and presents two theoretical limitations.

- Organic structure vs organic behavior. Organic structures are described as complex organizations with lower formalization and centralization. Yet what is « an organic structure » ? What is the difference between an organization that *adapts continuously its structures* and an organic one ? The two formulations are equivalent. This means that the notion of organic structure is misleading. There is no such thing as an organic structure. And it is more accurate to speak of an «organic behavior in organizations » which generates evolving structures.

- Organic behavior and creative behavior. If organic behavior is robustly correlated to innovation, yet do all forms of organic behavior generate innovation ? Obviously, it has to be the type of behavior that *produces new knowledge and new ideas*. Hence, for innovation organic or evolving behavior is not enough. Moreover, it is well known that innovation requires different types of behavior according to the phases and issues of the process. Let us consider the activity of designing and testing a prototype. If the designing phase needs organic cooperation between several skills, the testing phase should be a mechanistic one if tests have to be performed according to very tight rules. Yet, if some surprising phenomena appears during the tests organic behavior will be required again.

1.2. Now, what are the determinants of an organic and creative behavior within organizations ? This is, in our view, a consistent and fruitful way to departs from the traditional inquiry looking for the best structures adapted to innovation. Our hypotheses are the following :

H0 : Organic and creative behavior can be inhibited by structural rigidity and high formalization : H0 seems a good reformulation of the main findings of the literature**.** We interpret them as a useful negative result. Structures can limit the capacity to innovate. They cannot create it. Thus our research program have been oriented by the complementary hypothesis H1.

H1 : Organic and creative behavior cannot be obtained or stimulated uniquely by the weakening of structural constraints. It needs what we will define *as innovative design strategies, design rules and design cultures.*

1.3. Hage's «missing variable» : revisiting work division. H1 can be related to the notion of « complex division of labor» which has been emphasized as the « missing variable » (Hage 1999). For Hage complex division of labour is important because it « *refers to the intellectual or problem solving or learning capacities of the organization, to say nothing about the creative capacities* » (Hage 1999). Our line of thought is close to this perspective. But Hage's formulation maintains innovation research within a structuralist paradigm of organizations. We consider «complex division of labor», if defined as Hage does, as a *consequence* of organic and creative behavior. This means that during innovation processes the notion of « division of labor » has a different meaning than the classic and well established one. **It is not the allocation of a fixed list of tasks to persons or units.** It is a design process that within a first structure (say a unit of mechanics and a unit of acoustics in an R&D department) *generates new issues* (some problem appears and there are different solutions either mechanical or acoustic or both) which are contingently allocated according *to design rules and trade-offs* (the selected solution creates a new distribution of tasks that may changes the boundaries and competencies of the two units). To put it short, we think that *the division of a design work is not the same issue than the division of a routinized work*. We will come back later to this point in section 4.

1.4. Innovation and learning in the organizational literature : the crucial role of design metaphors. Besides the structure-conduct performance paradigm, a large current of the organizational literature emphasized learning processes, knowledge management, absorptive capacities and networks. It is beyond the scope of this paper to survey all these trends. However, its main findings underline characteristic features of design processes or use Design metaphors.

- Innovation needs the active interventions of several networks of participants that contribute to transform the initial ideas and make them more concrete and viable (clients can also be useful participants) (Callon 1986; Van de Ven et al. 1999; Whitley 2000). This means that innovation needs a collective and active *design* process ; yet, all the designers are not necessarily known at the beginning of the process.

- Innovation needs a complex learning process in uncertain contexts. It goes from « tacit» or broad knowledge to explicit and specific one (Nonaka and Takeuchi 1995) ; it is oriented by strong experimentalism (Leonard-Barton 1995). These are common features of any design process be it artistic, architectural or involving engineering work.

- Innovation needs some forms of « mapping », « guiding patterns », or « framing » (Van de Ven et al. 1999). All these notions are metaphors of a design orientation, a design rule or a « brief »[2].

1.5. Innovation capability, design rules and organizational behaviour. Other series of results support directly the idea that design rules and cultures support organic and creative behaviour :

a) **The « jazz metaphor » in organizing**. Karl Weick (Weick 1998) suggested « jazz improvisation » as a good metaphor for new ways of organizing for autonomy and creativity. « Jazz improvisation » is a good example of a local design work (improvisation) embedded in an overall set of design rules (theme, harmony, rhythmic, swing..) and an organizational process (the band, the rehearsals, the instruments..). The combination of these elements allows the jazz soloist to be « innovative» within some shared and agreed upon limits. Jazzmen can improvise freely provided that they respect these rules and do not attempt to transform a piece of jazz in a piece of classical music ! Hence, *Jazz design rules allow for an innovative organization* : a professional and organized orchestra trained for creative variations.

b) **«Latent organizations » in cultural organizations.** Starkey et al. (Starkey, Barnatt and Tempest 2000) showed that cultural companies (TV companies) presented an organizational form that was different from network or hierachy which they called « latent organizations». During long periods of time, TV companies used to hire, repeatedly, almost the same teams for their projects. What explains these « latent organizations » ? It seems that it is the design capabilities that are recognized to these teams. « Latent organizations » can be considered as the *a form of team tenure in spite of a free job market*. These teams are vehicles of design cultures well recognized by the companies.

Let us summarize our perception of the findings of the innovation literature : **i)** innovation cannot be defined by a fixed set of structures but by *an evolving process of design actions and relations that create a sequence of structures ;* **ii)** The innovation process is always described with metaphors that belong to *the Design tradition* : architecture, mapping, framing, patterns. **Yet to our knowledge no constitutional link between organization theory and design theory has been considered.**

This explains, in our view, the limited influence of the innovation and learning literature on management practice. Left with no clear organizing principles, no clear meaning of what is « good mapping », « framing » or « networking », the development of innovation capability has

---

[2] Different types of innovations have been distinguished in the literature : radical or incremental, architectural, generic, craft based etc. However, these distinctions cannot be established in absolute terms. This is well known in Design : the point of view of a client about radicality or incrementality may be completely different from an expert's or a designer's.

been identified in management to the development of project, multiproject, or platform management, to improved R&D or to knowledge management. These proposals seemed more actionable that the « innovation journey » (Van de Ven et al. 1999) or the « learning organization ». *Our claim is that introducing design theory clarifies an old organizational enigma concerning innovation.* An Innovation capability is not only an organizational capability. Organizational principles or structures are not innovative per se as we thought in the sixties with the concept of « organic structures » (Burns and Stalker). These principles have to be combined with specific design capabilities. But how can design strategies and organizational principles be combined to generate organic and innovative behavior ? *And are there companies that developed this capability in a persistent, successful and sustained way ? And what do they tell us ?*

Section 2 : Innovative companies : two case studies

Our research program (Chapel 1997; Hatchuel, Le Masson and Weil 2001) attempted the study of companies that showed *a clear capacity to innovate repeatedly on long periods of time*. The methodology was qualitative and necessarily historical. We combined : i) deep collaborative research during three or four years ; ii) and historical research in order to capture the generation processes that produced innovative design capabilities and specific organizational behavior. In this paper, we summarize the findings concerning two contrasting cases : *Tefal* a fifty years old company devoted to kitchen and home equipment and *Sekurit St Gobain* a one century old company specialized in the making of windscreens for the car industry.

To capture the innovative capability of these companies we didn't focus on the adoption of isolated « innovations », nor on some rate of innovations. We analyzed the history of the products, the history of their skills and know-how and the evolution of their organizational behavior. We found that they both struggled to design simultaneously « lineages » of products and « lineages of competencies ». This allowed them to develop *an interesting growth logic* : they used incremental product innovation to develop a radically new competency or they designed radically new products with well known competencies. This is a good illustration of what can be seen as **a design strategy** regulating the growth and competitiveness of the company.

a) The TEFAL case 1974-1997 : innovative design strategies as the managerial core of a company

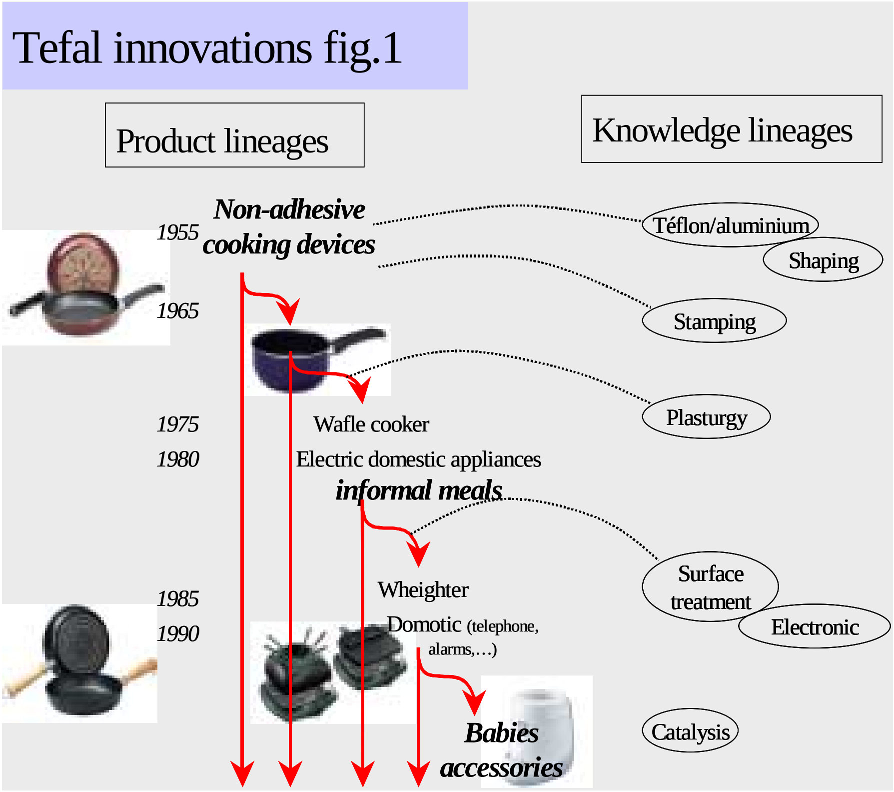
Tefal is a company belonging to the French group SEB. During at least two decades, this company showed a very successful and innovative growth (Chapel 1997). The company became famous for its Teflon-coated pans in the sixties. Then it showed a sustained ability to develop innovative products in the very competitive sector of domestic goods for cooking and home-keeping. While many of its competitors tried to win market shares by developing production units in low-wages countries, Tefal chose to innovate permanently and to create new businesses with high value-added products allowing high profit rates. During at least one decade Tefal appeared as one of the most profitable company in its sector. Their strategy of "repeated innovations" (Chapel 1997; Hatchuel et al. 1998) emerged rather early in the history of Tefal. It seems that the uncountable properties of Teflon coating was one of the impetus that lead the managers and product leaders of Tefal to progressively organize a *collective process of innovation* quite different from a classic research department and from a standard engineering design unit. It is not possible to account for the whole history of Tefal, but at least during a period of one decade it was possible to assess the following distinctive features of an innovation process built around a combination of Design strategies and organizing principles.

A high-level innovation committee: it is a meeting regularly and directly headed by Tefal's CEO. The committee was charged to launch new ideas and concepts and to monitor their maturation process. It was composed of all the functional departments and of all the « innovation teams » (see below). One of its main role was to identify, through new products, what we called "innovation fields" : a set of concepts that designate a new area of product development and/or competency development. Hence, the core design strategies of the company were both centralized and participatively discussed.

The innovation teams: **a couple of interrelated competencies.** An «innovation team» was composed of a product engineer and a marketing specialist who studied together each accepted new innovation field and concepts. This dual team had to transform the new concepts in new propositions of products (or family of products) by activating all the functional units of the company and external competencies. This team cannot be defined as a « cross-functional » as the two members progressively invented a behavior different from a classic product engineer position or a marketing specialist. The team had both to define concepts and to organize their exploration. This position do not fit also with the classical distinction between lightweight and heavy weight project leaders. Their influence and mobilizing capacity inside the company was not pre-established but was largely dependent of the content and evolution of the concept they proposed .

A culture of collective design through «prototyping » discussion : the role of the innovation committee in the treatment of new concepts was essential. A concept that seemed not very promising could suddenly become very attractive at a meeting and therefore receive legitimacy and priority by all the departments. The « innovation groups » tend to go as fast as possible in transforming a concept in mock-ups or experimental prototypes that could be discussed, criticized and improved at the committee. The political arena of the committee impulsed a specific logic of «rapid prototyping » destined not only to validate technical details but also to stimulate discussion on concepts and to mobilize the multiple expertise available in the committee.

Product lineages and design strategy: innovating within self-imposed dominant designs. The Tefal way of "repeated innovations" created a need for both stability and change. New designs appeared interesting if they create important learnings at a reduced risk. In the literature, a Dominant design is usually defined as the design standard selected by the market. But from another point of view a dominant design is a "design strategy" : a selected combinations of design choices and related competencies that allow for a long term and large scope of product development and improvement. In the Tefal case, identifying design strategies appeared as a well established intentional process that has been historically learned by the managers in the early years of the company. The first development of Teflon-coated pans was interpreted not only as a technology push (Teflon coated on aluminum sheets) or a market pull product, but as a « *design strategy* » leading to a wide area of cooking instruments and supporting a new set of values linked to new cooking habits and to new gender status in contemporary societies. Hundreds of products were and are still developed within this design strategy. Moreover consciously formulating "design strategies" allowed to understand the development of *deviant ones* that opened the way to new product lineages. In the beginning of the eighties, the development of a waffle cooker needed electric heating and specific plastic structure in addition to the Teflon coated process. This deviant opened a new lineage which gave birth to a new product division as successful as the Teflon coated pan one.(see fig.1 for a schematic representation of the product lineages).



Knowledge exchange across innovation teams and product lineages. The flow of new emerging products was also a vehicle for exploring new knowledge and new competencies. However, if not all concepts ended in accepted products, several knowledge that was produced for the maturation of a concept was finally used in another context. An example of such transfers can be found in the fact that the experience gained in a less successful electronic device was finally an important input to a very innovative improvement of home weighters. A thorough longitudinal study of the Tefal products shows that such transfers have been almost systematically explored (Chapel 1997). One of the striking effects of this process is that *the old Teflon coated aluminum pan is still a blockbuster* precisely because it benefited from technical competencies acquired *in younger* series of products ! This design capability to spin off knowledge is favored by the logic of "product lineages".

The Tefal case shows a unique combination of design principles and organization principles that has been developed and learned across time. *A quick organizational study of Tefal would have given no particular information on these features* : the names of the departments are classic, the product committee exists in many companies ; the specific behavior of the innovative teams is not easy to identify by interviews. The only signs that would have permitted to foresee a specific model were given by the amazing development of hundred of innovative products during decades.

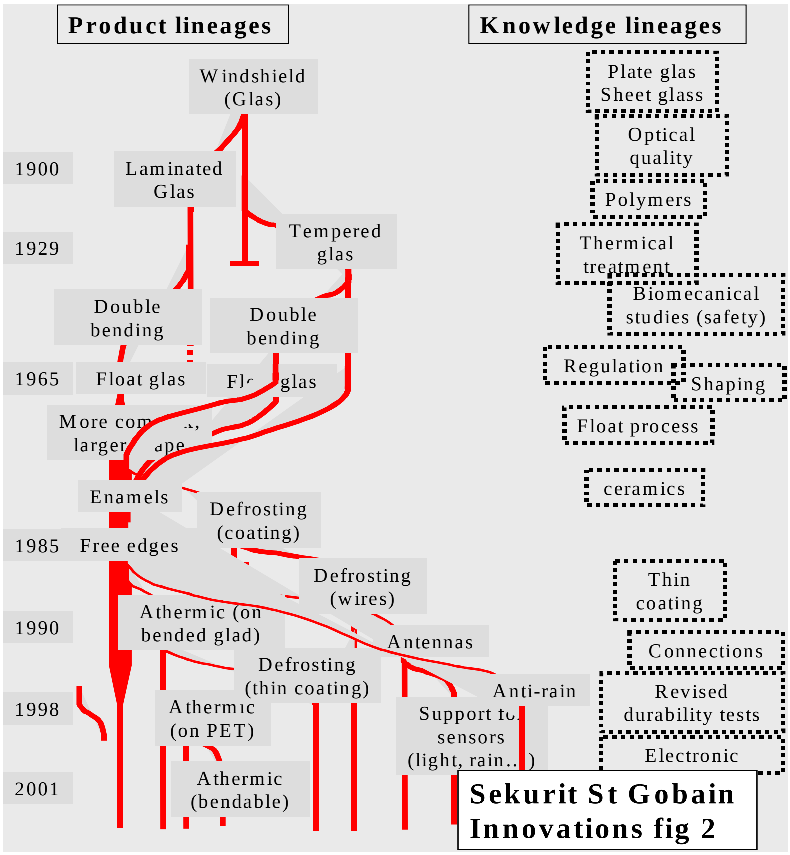
b) The Sekurit St Gobain case : rebuilding R&D as an innovation capability

This second case (Le Masson 2001; Le Masson, Hatchuel and Weil 2000) differs from the Tefal case. The history of Tefal showed a maturation and expansion of the organization around its innovation process. This second case shows a *sequence of organizational models* that corresponded to different regimes of innovation and therefore to different design strategies. It the last decades, it shows the shift from an innovation regime based on a dominant design of the product, *to a new regime, similar to the Tefal one*, where several lineages of products become possible with many interdependencies and complementarities. This case shows also the importance of changing the design dynamics (including research) and culture in the generation of new innovative behaviour.

1965-1995. Innovating within a dominant design : Saint-Gobain Sekurit is the European leader in car glazing. Until the mid 90s, car glazing embodied a typical dominant design : the 3D shape gave the main performance criteria (the more bended, the best). Ten other specifications (durability, strength, optical quality…) were carried over from product to product without discussion between the car designer and the glazing unit designer. This dominant design was fully consistent with a classic and efficient R&D structure where a powerful research department developed advanced knowledge about glass bending and a development department warranted that each product met its specifications. This organization limited the innovation capability in two ways: i) any new skill had to be consistent with the complex and sophisticated knowledge about specific glass for the car industry; ii) any new specification had to be consistent with all the car constraints as well as the present dominant design.

1995-2000 Getting into intensive innovation : after some years of learning, this conservative strategy was changed with substantial results. Saint Gobain Sekurit is today putting a lot of new products on the market and, in spite of a slow growing market, is hitting an impressive 8% level of annual turnover growth since a couple of years. All these products have now new functions different from the old dominant design and require new skills. The overall logic of the design activities has deeply changed. The R&D structure was transformed through the birth of an "innovation lab" that included the research labs. This "innovation lab" had both to submit new questions to the research labs (whenever they are related to scientific disciplines) and to provide the development departments with innovative types of products (as athermic windshields) with reduced risk. Thus the innovation lab had on one hand, to trigger research and on another hand, to work with the customers in order to establish new specifications and new skills validated by prototypes or small series (level of energy transmission through the windshield, sputtered nanometric transparent metal layers). This innovation lab had consequently *an unusual scope of activities* : the design of prototypes and new products that are too innovative to be treated directly by the development department, the exploration of generic functions in cars (as thermal comfort or communication) that could lead to new glass products, the management of meetings and working groups with design experts from the car makers. Now, how such a new capability emerged ?

The emergence of an innovative design strategy Detailed investigation showed that there had been no organizational revolution, nor formulation of a new strategic vision. It has been a stepwise and learning process *led by new product concepts and new customer requirements* that impulsed a new design strategy (see fig.2 and 3 for a brief overview of the evolution).



Sekurit St Gobain Innovations fig 2

An important event occured when the "research lab" was suddenly asked not to treat a scientific phenomena but *to take charge of an emergency project concerning the design of athermic windshields*. This first move was followed rapidly by other ones. Each project was bringing a new function and new specifications to the simple "car-glazing". One important feature of these projects was that they needed the skills (know-how, instruments) of research people *without being classic research work* ! These new style of products were well accepted by researchers as this "project" logic enacted a new logic of competition through innovation.

Yet, the number of new projects rapidly exploded. With the multiplicity of new required skills. This settled a new strategic issue: the good old "commodity" car-glazing was becoming a multifunctional product with a large number of new possible functional lineages . An analysis of successful projects also showed that success and efficiency were due to the reuse of knowledge acquired in previous projects and not necessarily applied in the "parent" project. The lab was then progressively organized according to functional lineages of projects i.e. group of projects requiring the same design logic and a common core of skills. Lineage leaders were appointed, they were responsible for the growth of one function and/or one technology along series of projects, be it product projects or competency projects. There was for instance an "athermic" lineage working on several interdependent projects and technologies, designing a whole strategy on athermic windshield, asking for research studies in other research labs and regularly providing the development department with new and reliable product families that could be offered to the car maker.

This was not the last step! If the product was now multifunctional, growth would come from a reasoned development of new functions and new sources of value. This meant identifying *a new concept of a car glazing*. A *3D-shape in glass* was the main concept behind the old dominant design; the introduction of *one new attribute* was the concept of the project era; *a car-glazing with a common mix of functions* corresponded to the lineage organization. In this new phase, designers began to think of car-glazing as an "isolating-communicating membrane". This new concept triggered innovation as it revealed missing design areas. Therefore, new small teams were launched to explore very rapidly the "missing" aspects through cheap and efficient prototypes and "exploratory partnerships" with car maker designers.

R&D Organization at Sekurit-Saint-Gobain 1995-2001

1995- Research lab structure	Departments : organic chemsitry, inorganic chemistry, physics, optics, technology Work organization: several small research "projects" for each researcher
1998- Project organization	Matrix structure: same departments + a small number of NPD projects Projects names: athermic windshield for Renault, multiconnection for BMW, defrosting coating for Audi,…
2000- Lineage organization	Emergence of "competence cells": connection cell, athermic cell,... (in charge of monitoring several projects and creating tools and knowledge for future NPD projects)
2001- Innovation organization	Emergence of "exploratory projects": low cost, fast exploration of an innovation area (fictive example: making use of active glas surface for communicating with other car drivers)

c) From cases studies to theoretical issues : a critical view on R&D In spite of contrasting contexts, these two case studies show common trends and suggest the same theoretical remarks. Yet, it is important to mention that the role of the case studies in our research is not to validate any universal link between variables but to characterize both empirically and theoretically a *new model* of organizational behaviour and rationale. *A model that could have been predicted theoretically if we had the good theory!*

The Tefal model was born from the unexpected meeting between a very old and common tool, the pan, with one of the most modern forms of material : the Teflon polymer. The Design of a pan was ageless and straightforward, but the properties given by Teflon coating to the pan opened a new set of values and re-opened the design issue. A new universe of goods became possible provided that the organization supported its exploration. Yet, in this new unknown world, *design strategies became the guidelines for the structuring of the organization*. Design strategies oriented the organic behaviour of the first teams in their progressive generation of new competencies and these competencies, once established, stabilized profitable products, skills and departments. And then, new Design strategies triggered again the whole process while benefiting from the past knowledge produced, and so forth...This theoretical scheme requires in practice severe conditions before becoming reality. Obviously, it needs customers that are able and willing to pay for the continuous innovation process. It requires also, that some rigid dominant design is not maintained by a dominant coalition of customers and competitors. But when it becomes possible it gives birth to a form of innovation driven competition that submits companies to unusual constraints and challenges.

One of the most striking observation that occurs when we compare these two cases is that the old and heavy company, Sekurit-St Gobain, that maintained a huge research effort since decades, only recently entered such type of competitive environment. When it happened, *the design of a windscreen became not a product issue but a strategic issue, likewise* the design of pans became strategic when it incorporated the Teflon properties. Thus in recent years, the organization of the two companies became similar, *not in their structure (there is no pure research department at Tefal) but in their fundamental behaviour and design logic.* In both cases, innovation became the result of a systematic, intentional, repeated, paced and conceptually shaped Design strategy. This strategy triggered the core "metabolism" of the firm because it gives rules and meaning to organizing tasks. Products may fail at the market, concepts can be abandoned or projects cancelled, all this became part of the routine behaviour of the company, provided that it generates a sustained profitability.

Therefore, if Tefal and Sekurit can be considered as examples of a new model of organization, the advantages of such model are obvious. *We can reach a more operational picture of what means being an innovative company*. However, we cannot only describe that picture with structural principles. Even the idea of the "innovation lab" would lack any value if we cannot clearly describe the type of behaviour that is generated in this lab. So what was missing in organization theory that explains the novelty of this model ? There are several ways to discuss this issue. We will mention two of them which are central for our research :

- The basic language of organization theory has been shaped by *a production paradigm* coming partly from the economic tradition : organization are described by set of tasks that have to be performed by agents : yet the *definition and generation of these tasks (their design)* is not taken into account or simply related to some set of existing skills or knowledge resources. Also, the sociologic tradition has rarely considered the operations of Design as a subject per se and it has only insisted on the necessity to have a good cooperation between professionals be it designers or not.

- The notion of R&D has served as the self-evident way to describe the Design capacity of a company. Thus design was reduced to the ability to apply efficiently the knowledge resulting from research, provided that Marketing departments gave some information on the expectations of the market. Product development and innovation were viewed as different research fields. Finally, design theory and the operational logic of Design have been forgotten limiting our understanding of innovation and our capacity to detect and identify new forms of organizations.

In the next section we are going to introduce some elements of design theory in order to ground all these discussions on a solid theoretical framework. This framework will be used to discuss a new concept of organization, of which Tefal and Sekurit are contingent realizations. Then, we will compare this organization model to more classic ones.

Section 3. Design theory : the concept-knowledge approach

3.1 Elements of a unified approach to design

Why is it difficult to theoretically define « design » ? We all know that architects design buildings, engineers design complex technical equipment and stylists design shapes and symbols. Yet, this doesn't tell us what is Design ? Or, what have in common all these professionals in spite of their different domains of expertise. There is an important literature about design but it is split into these different professional areas, and there are very few attempts to reach a unified and domain independent design theory. In practice, design is described as a sequence of *tasks* to be performed : establishing requirements, defining alternatives, validating and selecting solutions. This language misses the content of design activity and only describes usual *design planning*. What can be said of Design in terms of *content, output or effects ?*

a) Design : inverting the « representation » of things : The content of Design is difficult to capture because we use to think about « things » *as if they existed and if the problem was to correctly « represent » them*. Moreover, when we experience design situations we tend to reflect about them not in terms of design theory but in terms of problem solving or decision theory (Hatchuel 2002; Hatchuel and Weil 2002; Hatchuel and Weil 2003). For example, many of us whom organized a « nice party » will remember the moments where hard choices had to be done. They rarely think about the whole process as a design one.

b) The operations of Design : how do we expand concepts ? We introduce now some elements of a design theory (Hatchuel and Weil 2002; Hatchuel and Weil 2003) that can be directly useful to innovation and organization theory. Let us use the example of a « nice party having the properties I desire » (to put it short we will say « nice party »). Designing « a nice party » (alone or with a group of friends) inverts the logic of representation : we are not only attempting to describe parties that already happened. Yet, we may use knowledge coming from this memory. The « nice party » we want to design may look like the old ones but it doesn't already exist. Let us call a « concept », the expression «the nice party that I want to organize with the properties I wish ». Designing means : i) that this concept doesn't describe, represent or define an already existing party, yet it is acceptable and understandable as entry for a design team ; ii) that we can't immediately define what will be this party (if I decide to copy as exactly as possible an old party, design is reduced to past knowledge and routine). Thus Design activity contains operations by which this « party concept » will be transformed tentatively in different outputs ; only one of them is a defined party as we are also producing other concepts and new knowledge. From this, we can formulate some basic propositions about design activity.

c) Design entries and concept expansion. Design begins with the «presentation » of concepts (they can be verbal or non verbal : a drawing, a short melody…). Hence, concepts do not describe one thing or a family of things but they formulate *a design entry and orientation* that mades further design work possible. This is directly linked to organizational issues : design concepts do not describe tasks but *makes them possible*. If the party concept is formulated as a « fancy dress ball », few has been said yet the design work has made enormous progress : the initial concept has been more closely defined through an expansion of its formulation. Hence, designing is defining by an expansion of the concept attributes[3].

d) Design expands «concepts » through different « design spaces » (Holmberg, Le Masson and Segrestin 2003). Whenever the party is declared as a « fancy dress ball », the world of « fancy dresses » creates a « design space » : a space where we can ask which kind of fancy we want ? which one can be found easily ? Should we let party members invent there own dresses ? suggest a « dress code » ? Within a design space existing knowledge can be used, but also new knowledge can be generated : it is easy to imagine that a visit to a specialized fancy dress shop creates a learning process that can generate new concept expansions : for instance, one could learn there that we can combine a fancy dress ball with some party events or performance…This highlights a central design procedure : concept are expanded through design spaces, which need old knowledge, but also generate discoveries and investigation processes that in turn expand the initial concept. Thus within a design space new dimensions can be added and new design spaces appear. For example, Designers often « expand » a two dimension drawing (the rough drawings) in a 3D solid object (a mock-up) which helps to introduce new dimensions like assembly possibilities. We have given elsewhere a more thorough presentation of this design theory (Hatchuel and Weil 2002; Hatchuel and Weil 2003). However, these elements are enough to emphasize, in the next section, :

- the theoretical implications of this approach on innovation and organizational theory
- the interpretative power of this approach regarding our cases studies and the emergence of new organizations in contemporary contexts

---

[3] The specificity of such « Design/definition » process has been formalized by the philosopher J.W. Miller (Miller 1980).

Section 4. Design strategy, Innovation and organizational dynamics : towards design-oriented organizations

4.1. Design strategy, knowledge metabolism and innovation : an interpretation of the case studies

The first result of our approach is to clarify the logic by which Design work acts as a « metabolism » of knowledge (and learning) in the organization. We use the «metabolism» metaphor because Design both activates existing knowledge (stimulates existing resources and use them at relevant places and moment) and helps to generate new ones (creates resources). One central mechanism of this metabolism is the use of concepts which in spite of being «understandable fictions » are a necessary work entry for any design. Still, concepts do not fully control the metabolism of knowledge nor determine it. They limit or enlarge its scope and logic of expansion. Moreover, design concepts form the basis of **a design strategy** when they are used as **management tools** regulating the knowledge metabolism. To illustrate this process let us change the context of our example and imagine a company offering the service of organizing « fancy dress balls » for clients. Now we can easily formulate some hypothesis about how the design strategy will impact on innovation through the knowledge metabolism. *Two contrasting cases of Design strategy can be idealized :*

- **Routinized metabolism** : the type of « fancy dress parties » offered is conceptually defined by some fixed list of design spaces (the client is asked to choose in lists to shape the desired party) and the knowledge metabolism is limited and oriented by these lists. A stable division of knowledge areas becomes possible. Learning (including research) and innovation are still possible but they are oriented by the concept. *It is not a model of knowledge exploitation but a model of oriented exploration.* After some periods of time, the company has reached a dynamic equilibrium which allows a stable division of work design. Yet, it is not a routine company ! It is a company that has routinized its design processes : innovation is perfectly possible yet within a stabilized metabolism (Jazz or football are good examples of such form of routinized innovation)

- **Non-routinized metabolism** *:* in this case, the type of fancy party offered is not conceptually defined by a list of choices or by some standard rules. The knowledge metabolism is widely open. A stabilized division of knowledge areas is difficult to maintain ; learning can change the design spaces in unexpected ways and even the initial concept could be regenerated. Innovation can occur at all levels of the processes.

Obviously these are pure idealistic cases, yet one can theoretically conjecture than non-routinized metabolism requires *intensive design strategy* and that companies that are able to *combine both models of metabolism* will present special features.

- The Tefal case shows *a striking example of how non routinized metabolism is used to launch new lineages and products*, and thus to foster new knowledge capabilities. The work of the high level innovation committee is precisely to equilibrate the tensions between the two design strategies and to cross-fertilize their outputs. Whenever a new family of products appears it is both important that it reached a routinize metabolism and that it allows non-routinize metabolism even if the learning created is not used in this family. This explains : i) how old products like pans are still innovative and profitable using knowledge developed by younger family of products like scales ; ii) how new family of products can benefit from old family of products as «surrogate mothers ».

- *the Sekurit St Gobain case shows how an R&D department is transformed when Design strategy is more and more generating non-routinized behaviour*. It shows also the importance of the conceptual work done on car glazing in order to allow for numerous knowledge expansions. It highlights also *the role of the client* in such transformations. Non-routinized metabolism is almost impossible *if clients are not willing to accept and share the new offers*. Innovative capabilities have also to be supported by the network of suppliers (not all of them but at least one part of them).

4.2. Revisiting organizational theory : Design strategy and metabolism as missing variables

In terms of organizational theory, these two design strategies are not clearly captured by classic organizational types or variables (Damanpour 1991).

- **Organic behaviour** can be observed in both cases but the content, purpose and target of this behaviour is not the same in each case. In the Tefal case we can notice a strong exchange of knowledge between different lineages of products. In others company the organic behaviour could exist only *within* product families. Hence, it is not the « organic » character of some behaviour that counts but on what and when do it occur.

- **The number of specialties** is not a relevant variable for innovation. What defines the non routinized metabolism is not the number of concerned knowledge areas but the *renewal and expansion of these specialties*. In both case studies we can observe periods of rapid increase of new specialties and periods of relative stability : obviously innovation capability is linked to this ability to reshape and create specialties.

- **Degree of formalization** : this variable is defined as the degree of *task* specification ; in design this is a notion that could be misleading. Design tasks can be specified in detail without determining the content of concepts (products) and knowledge areas produced. Moreover, a high specification of concepts is not distinctive of routinized or non-routinize metabolism : for example, high complex equipments require extensive conceptual specifications (functions, contexts, usages, …) and we could find both types of design strategies in this sector. What should be considered is the logic of concept expansion, the variety of design spaces considered, the explored knowledge lineages

.

- **Centralisation** : in Design, centralization per se is not a source of technocracy. If centralization reinforces a logic of routinized metabolism it will diminish the innovation capability ; if centralization allows conceptual expansion and renewal of design strategies then it will favour the rate and scope of innovations.

All others classic variables (managerial attitude of change, managerial tenure, professionalism) can be revisited in the same perspective : *what counts is the meaning of these variables in a design context and not in general*. We have also discussed earlier Hage's «complex division of work ». We can confirm that in design « complex division work » means at least three different things : the regeneration of concepts that can create multiple lineages of interdependent products in the company ; the renewal of knowledge areas stimulated by new concepts ; the exchange of knowledge between product lineages and the impact of the prototyping strategy on the design processes.

Therefore one important conclusion is the following : if there is a contingent theory of innovative capability in organizations, the contingent variables are necessarily *descriptors of the design process*. And C-K approach offers a powerful framework for such contingency perspective.

4.3 C-K distance : a metaphor of design intensity and innovation potential

The simplest way to capture the design process is to trace the reciprocal activation of concepts by knowledge and conversely. Hence, the intensity and innovativeness of a design situation can be imaged as a c*oncept-knowledge distance*. (C-K distance). The « bigger » a C-K distance is perceived, the more a non routinized metabolism becomes possible, the more the potential for innovation, the less a structural view of the organization is relevant and the more Design has to be managed and guided by a strategy !

- **The notion of « C-K » distance :** it is a cognitive, and metaphorical one. Can we consider it as a countable measure ? Obviously it has to be evaluated by the group of designers them selves and relatively to their own knowledge. A proxy of it could be the relative number of design strategies that are opened by new concepts within specific knowledge base. In a context of routinized metabolism, new concepts can be almost fully designed with existing knowledge. In such case, the number of design alternatives seems rapidly reduced ann designers think that they can quickly find an acceptable way. If a non routinized metabolism seems required, it's quite the contrary. *New concepts seem to open almost infinitely various alternatives* each one corresponding to new knowledge expansions, i. e. knowledge that is not available or which existence cannot be assessed immediately. In such circumstances the C-K distance would be seen as relatively high.

As the design process is necessarily a social and organizational one. A big C-K distance means that different people and teams will have to cooperate along several, evolving and expanding heterogeneous design spaces. We have seen that this is the core of the innovation *capability*.

4.3 Classic organizations and Design oriented organizations : a contingent perspective on contemporary emergent organizations.

Thus, innovative capability is nor simple creativity, nor research capacity, nor technological capacity, nor good team-working, nor good networking. *It is an individual and an organizational capability focused on design strategy and design work.* A capability which development and learning is ruled by the logics and intensity of design. Then, if C-K distance can be used as a metaphor of design intensity, it can also offer a new contingent view of organizations. Such contingency approach has two stakes : i) Characterise well known organization types with this contingency scale. Ii) identify a model of organisation that could capture the main features that we have earlier described in Tefal and Sekurit St Gobain, a model that we suggest to call *« Design oriented organizations » (DO2*)(Hatchuel, Le Masson and Weil 2002) .

a) Revisiting classical organization theory with C-K distance as a contingent variable

- Bureaucracies, sports and artistic organizations : The classical Bureaucracy has been always seen as a routinized and standardized organization. It probably never existed purely, but the notion described organizations where design work and design strategy is very limited and the innovation capability also very limited or invisible. In pure theoretical terms, classic bureaucracies are organizations where *the acceptable C-K distance in design is obviously very « small* ». This doesn't no mean that the knowledge and competencies of the company is limited ! But that **new concepts are introduced only if they are quickly interpreted and designed within the existing knowledge or within limited expansions of it**. One interesting result of this approach is that collective sports, orchestras (including jazz), dance an theatre are organizations where infinite variations of behaviour are possible within a strong set of rules. These rules control the design capability of each member and maintain a limited C-K distance. Modernism in Art endeavoured precisely to increase the design capability of members by working with a greater C-K distance, yet not always acceptable for the audience. This proposition deserves a more detailed discussion that is out of the scope of this paper. However it gives some indication about the potential of such contingent view. And it throws also new light on the functional organizations that emerged for a more ambitious design work.

b) The functional structure as a stabilized innovation capability : the functional structure appeared with the developments of departments that had to suggest new rules to existing operational units. The functional division of work is generally structured by product areas (brands, organs, components) or knowledge areas (processes markets, sciences, professional skills). Functions are thus Design departments that produce design rules within a constrained *routinized design and metabolism process*. The functional organization was an innovation capability in a context of C-K distance that was increased but strongly regulated by the structure of the functions. It is the type of organization where the classic structural variables have certainly there more stronger impact, and this could explain the result of classic research. Also in functional structures, the *creation of new functions is often a complex change process if not a threat to the whole design process.*

c) Projects and Matrix organizations : an unstable step towards DO2 The matrix system is the first organisation that distinguishes between knowledge oriented units (the functions) and concept-oriented units (the projects, or divisions). The emergence of matrix and projects based organizations is in our view a sign of the necessity to increase C-K distance in design in order to cope with more competitive contexts and fast knowledge renewal. For this reason, in spite of their name *the functions in a « functional structure » cannot be similar to " functions " in a matrix*. In the functional structure, functions designs operations. In the matrix, both functions and projects claim to be design processes. Projects explore concepts that are not within the scope of existing functions and they can do it through external knowledge acquisition which is a form of knowledge expansion that became, not surprisingly, very popular in management since two decades. This is also why the matrix is unstable : it is a mix of routinized and non-routinized design that is not managed as such. It has not the capability to formulate design strategies and to support non-routinized knowledge metabolism. If the organization faces higher C-K distance, and if these capabilities are missing , permanent tensions will appear at both at the level of the top management and between the two types of units. Innovation will increase but it takes a « wild » and costly form : skunk work, conflicting projects, high mortality of new ideas…

It is one of the hypothesis of this paper, that such situations in companies paved the way to new form of organizations. New forms that we have observed in our case studies and which existence can be theoretically predicted within our contingency perspective.

e) Beyond matrix : Design oriented organizations: Design oriented Organizations (DO2) are not matrix structures. We enter the world of DO2 precisely when two types of situations occur repeatedly and with a high frequency in a competititive context :

i) a new body of knowledge is identified and could be explored, yet nobody knows which concepts could be linked to this exploration and could convey new products (for example the case of « technical » textiles or the « wap » standard in mobile telephony)
ii) New concepts are easily identified but nobody knows which body of knowledge will be necessary to transform the concept in acceptable products (for example designing a way to stop a car on very short distance even if it runs at a relatively high speed).

What are the organization principles that guide effective work and adequate work division in such conditions ? Classical bureaucratic theory will not help, its basic entries are missing : standards, outputs, skills are not yet defined ; they are the target of the design work. Mutual adjustment, the principle of adhocracies *has no operational meaning. W*ho is going to adjust to the other if no network is given ? So, what can be the logic of collective action in such contexts ? It is to increase the work on *Design strategies, principles, rules and to manage the non routinized metabolism associated with these strategies ; yet, without leaving a complementary routinized design process*. Tefal and the recent Sekurit St Gobain are very close to our model of DO2.

d) Management issues and logics in DO2 : a developemental view of design strategies :

The concept of DO2 is particularly useful to understand the enigma of repeatedly innovative companies. Like in Tefal and Sekurit St Gobain, one can predict no logic of daring endeavours or radical decisions. Instead we should observe a great deal of managerial attention permanently devoted to :

- **generate** and maintain « innovation fields » (Hatchuel, Le Masson and Weil 2001) i.e potential spaces of developement with big C-K distance) and simultaneously lineages of product using repeated designs (genalogy of products)
- **monitor** the expansions processes of concepts and knowledge by creating coordinated work groups with these two different logics
- **detect** all opportunities that can give birth to market products wich can serve as vehicles for the clarification and orientation of the expansion process
- **use** the design processes as a support for personal development for the greatest possible of employees.

Conclusion : capabilities to innovate and the making of design worlds

In this paper we have explored a new approach of the innovation capability in organizations. We have supported this approach with empirical and theoretical material.

- Empirically, we have chosen to deeply analyse, not innovations, or rates of innovations but the behaviour of companies that have been innovating successfully during long period of times. We have also given a detailed attention to the history of their products and to the type of knowledge (technical or not) that they have developed through their innovation history. This material has led us to focus our attention on Design work as a central process for the formation of these innovation capabilities. We have also observed that Design work, knowledge expansions and innovation were strongly interrelated aspects that formed a « metabolism » of the organization.

- to interpret theoretically these observations, we had to develop a new approach of Design that helped to operationalize innovation and offered descriptors of the design process and its close links to innovation. The C-K theory offered such descriptors in a rather simple way and with a real interpretative power.

- The concept-knowledge expansions, once recognized as a specific logic of design work, offered a good entry to interpret the two case studies of innovative companies presented in this paper. They also brought a new contingent perspective on organization theory. We could revisit bureaucracies, functional organizations, matrix structures and interpret them as attempts to cope with a higher C-K distance in the design process. The same framework can also interpret the existence of a form of organization that is better adapted to innovation based competition. These organizations that we call Design Oriented organizations have the capability to manage design strategies and to support non-routinized knowledge metabolism in complement to a routinized one. Our two case studies Tefal and Sekurit St Gobain seem very close to what we can expect theoretically.

Hence, by combining organization theory with design theory we can have a fresh and fruitful perspective on the development of innovation capabilities in contemporary contexts. The price to pay was to depart from classic structural variables and to mobilize design theory as a basic determinant of organization. For sure, Design is one of the most universal form of human thinking and acting. However, one central aspect of Design process is that it is not possible to consider work division independently of some design strategy. If work division controls design we get the structuralist view of organizations, if Design controls work division we have the functional view of organizations, if design and work division interact and foster a process of knowledge expansions hence we are entering the world of sustained and intensive innovative capability. This world suggests two concluding remarks :

a) I*nnovation capability is linked to the development of DO2*. People acting in such organizations will experience professional identities based on expertise renewal and increased design skills. They may experience the same type of role variation than comedians. Obviously, DO2 are highly selective companies. But with the diffusion of this type of organizations Design and innovation capabilities should become common skills.

b) *The making of companies or the making of design worlds ?* The concept of « art worlds »has been proposed by Howard Becker to capture the process of art production. We propose to describe as « *Design worlds* », those activities where we observe central design strategies and where personal and organizational development are oriented towards innovation capability. Cultural activities are obviously « design worlds » but we can also observe that many firms tend to present themselves as such : Apple, Sony, Nike, l'Oréal or Renault try to appear not only as producers but as « world makers » or creators.

With the concept of « Design worlds » we reach the front edge of our research. We have tried to show in this paper that linking organization theory and design theory was the key element to approach innovation capability. The « design view » is a necessary entry to understand the development of innovation, Art and Culture. Design creates worlds and invites people to participate to this making. Yet, a specific design theory was needed to identify how design strategy acts as an essential logic to both create collective action and offers managerial instruments for repeated and sustainable innovation.

Bibliography

Burns, Tom, and Stalker, G.M. (1961). *The Management of Innovation*, Social Science Paperback, Tavistock Publications Limited, London. 269.

Callon, Michel. (1986). "Some Elements For A Sociology of Translation: Domestication of the Scallops and the Fishermen of St-Brieuc Bay." Power, Action and Belief: a New Sociology of Knowledge?, J. Law, ed., Routledge & Kegan Paul, London, 196-229

Chapel, Vincent. (1997). "La croissance par l'innovation intensive : de la dynamique d'apprentissage à la révélation d'un modèle industriel, le cas Téfal," Thèse de doctorat en Ingénierie et Gestion, Ecole des Mines de Paris, Ingénierie et Gestion, Paris. 274p.

Damanpour, Fariborz. (1991). "Organizational Innovation: A Meta-analysis of Effects of Determinants and Moderators." *Academy of Management Journal*, 44, (3), 555-590.

Hage, J. T. (1999). "Organizational Innovation and Organizational Change." *Annual Review of Sociology*, 25, 597-622.

Hagedoorn, John. (2001). "Inter-firm R&D partenships: an overview of major trends and patterns since 1960." *Research Policy*, 31, 477-492.

Hatchuel, Armand. (1996). "Les théories de la conception.", Cours de l'Ecole des Mines, option Ingénierie de la conception. Paris.

Hatchuel, Armand. (2002). "Towards Design Theory and expandable rationality: the unfinished program of Herbert Simon." *Journal of Management and Governance*, 5, (3-4), 12 p.

Hatchuel, Armand, Chapel, Vincent, Deroy, Xavier, and Le Masson, Pascal. (1998). "Innovation répétée et croissance de la firme, analyses empiriques et conditions théoriques.", Ecole des Mines, Paris.

Hatchuel, Armand, Le Masson, Pascal, and Weil, Benoit. (2002). "From Knowledge Management to Design Oriented Organizations." *International Social Science Journal, Blackwell Publishing / UNESCO*, 171, (March 2002), 25-37.

Hatchuel, Armand, Le Masson, Pascal, and Weil, Benoît. (2001) "From R&D to RID : Design Strategies and the Management of Innovation Fields." *8th international product development management conference*, Enschede, the Netherlands, EIASM & UNiversity of Twente, 11-12th June, 2001, 415-430.

Hatchuel, Armand, and Weil, Benoit. (2002) "La théorie C-K : fondements et usages d'une théorie unifiée de la conception." *Colloque sciences de la conception*, Lyon, 15-16 mars 2002.

Hatchuel, Armand, and Weil, Benoit. (2003) "A new approach of innovative design: an introduction to C-K theory." *ICED'03, august 2003*, Stockholm, Sweden, 14.

Holmberg, Gunnar, Le Masson, Pascal, and Segrestin, Blanche. (2003) "How to Manage the Exploration of Innovation Fields? Towards a Renewal of Prototyping Roles and Uses." *3rd European Academy of Management*, Milan, 3rd-5th April 2003, 20.

Le Masson, Pascal. (2001). "De la R&D à la RID : modélisation des fonctions de conception et nouvelles organisations de la R&D," Thèse de doctorat en Ingénierie et Gestion, sous la direction de Benoit Weil, Ecole des Mines, Thèse de doctorat en Ingénierie et Gestion, Paris. 469p.

Le Masson, Pascal, Hatchuel, Armand, and Weil, Benoit. (2000) "Co-development to the test of intense innovation: towards new forms of organisation for innovative design in the case of car manufacturers and components makers." *8th Gerpisa International*

Colloquium, The World That Changed The Machine, Paris, Gerpisa, 32, décembre 2001, pp. 65-80, 18 pp.

Lenfle, Sylvain. (2001). "Compétition par l'innovation et organisation de la conception dans les industries amont. Le cas d'Usinor.,", Université de Marne-la-Vallée, Ecole Polytechnique, Sciences de Gestion, Paris. 354 p.p.

Leonard-Barton, Dorothy. (1995). *Wellsprings of Knowledge*, Harvard Business School Press, Boston, Massachussets.

Lundin, Rolf A., and Midler, Cristophe. (1998). "Projects as Arenas for Renewal and Learning Processes.", Kluwer Academic Publishers, Boston, 260.

Miller, John William. (1980). *The Definition of the Thing, with Some Notes on Language*, W. W. Norton & Company, New-York & London. 192.

Mintzberg, Henry. (1981). *The structuring of organizations : a synthesis of the research*, Prentice-Hall. 434.

Nonaka, Ikujiro , and Takeuchi, Hirotaka. (1995). *The Knowledge Creating Company : How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New-York.

Simon, Herbert A. (1969). *The Sciences of the Artificial*, J.-L. L. Moigne, translator, 1991, MIT Edition française : Bordas, Cambridge, Massachusetts, USA. 229, 1991.

Starkey, Ken, Barnatt, Christopher, and Tempest, Sue. (2000). "Beyond Networks and Hierarchies: Latent Organizations in the U.K. Television Industry." *Organization Science*, 11, (3), 299-305.

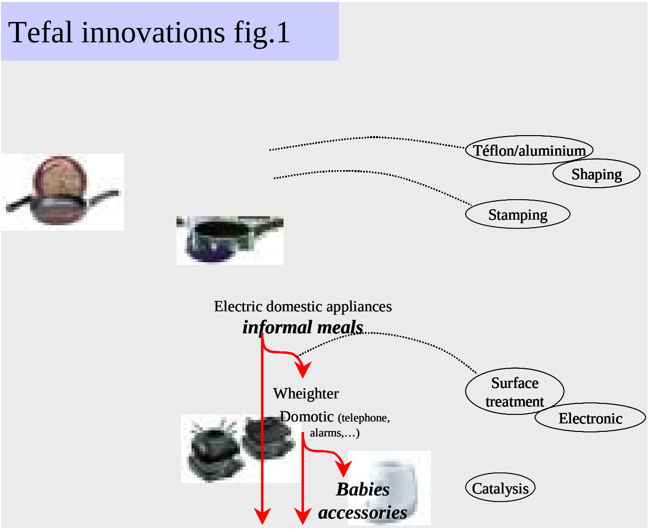
Van de Ven, Andrew, Polley, Douglas E. , Garud, Raghu, and Venkataraman, Sankaran. (1999). *The Innovation Journey*, Oxford University Press, New-York, Oxford. 422 p.

Weick, Karl E. (1998). "Improvisation as a Mindset for Organizational Analysis." *Organization Science*, 9, (5), 543-554.

Whitley, Richard. (2000). "The Institutional Structuring of Innovation Strategies: Business Systems, Firm Types and Patterns of Technical Change in Different Market Economies." *Organization Studies*, 21, (5), 855-886.

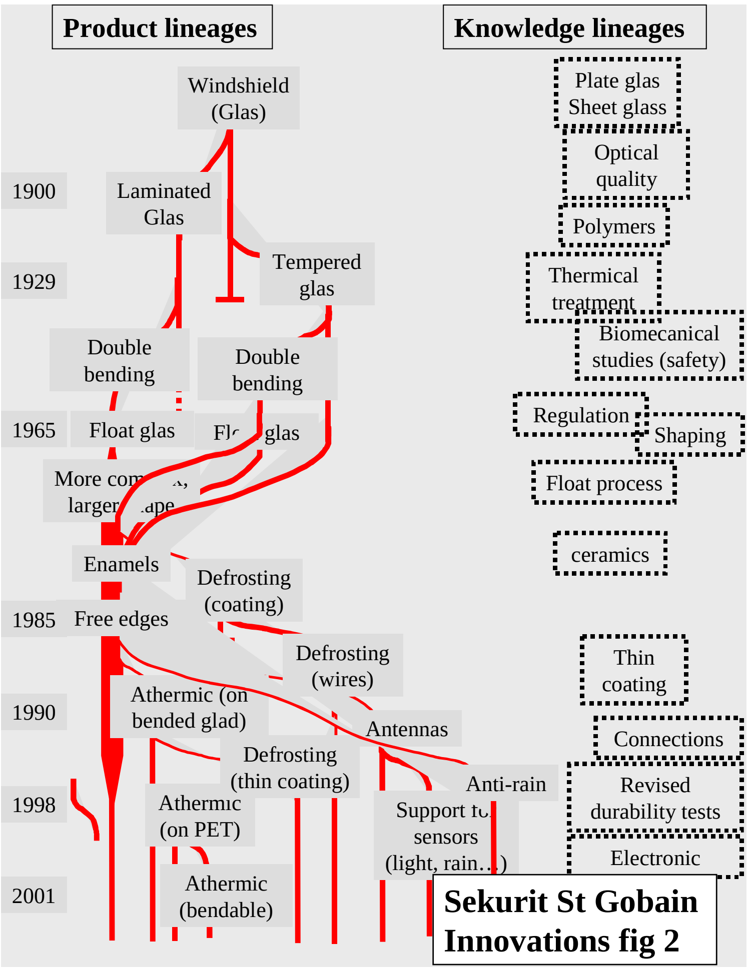
In spite This progressive emergence of what we have called an RID organization (Hatchuel, Lemasson, weil 2001) illustrates clearly the a underlined that this birth relied upon an evolving metabolism and this metabolism is described by describing the evolution of the type of concept and the type of learning processes that the company is able to address at a given moment: each step opens to new concepts (communication, thermic comfort,…) and invent new learning processes; based on theses, a new design strategy (and new organizations) become possible (windshield as a multifunctional product, lineage strategy…), and if successful it will give birth to new concepts and learning

It appears to us that the longitudinal study of an innovative company offers much more insights, concepts, and knowledge about the innovation processes than the classical comparative studies of different innovations coming from various companies [14,50]. The main reason for this is that isolating one product or one innovation is not significant of company or management processes. Company do not only design product, they simultaneously build competencies and they fight to maintain an efficient dynamic equilibria between products and competencies. This struggle gives birth to « design strategies », and innovative companies are companies that have developed processes where these design strategies can be built. Clearly it appeared from the Tefal case that establishing « design strategies » was not the job of development departments, not the job of marketing departments, but was the job of the innovation structures and processes: our hypothesis was that Tefal has invented and practiced R, I, D principles without explicitly formulating it.


Tefal innovations fig.1
Téflon/aluminium
Shaping
Stamping
Electric domestic appliances
informal meals
Wheighter
Domotic (telephone, alarms,…)
Surface treatment
Electronic
Babies accessories
Catalysis

R&D Organization at Sekurit-Saint-Gobain 1995-2001

1995- Research lab structure	Departments : organic chemsitry, inorganic chemistry, physics, optics, technology Work organization: several small research "projects" for each researcher
1998- Project organization	Matrix structure: same departments + a small number of NPD projects Projects names: athermic windshield for Renault, multiconnection for BMW, defrosting coating for Audi,…
2000- Lineage organization	Emergence of "competence cells": connection cell, athermic cell,... (in charge of monitoring several projects and creating tools and knowledge for future NPD projects)
2001- Innovation organization	Emergence of "exploratory projects": low cost, fast exploration of an innovation area (fictive example: making use of active glas surface for communicating with other car drivers)


Product lineages
Knowledge lineages
Windshield (Glas)
Plate glas
Sheet glass
Optical quality
1900
Laminated Glas
Polymers
1929
Tempered glas
Thermical treatment
Biomecanical studies (safety)
Double bending
Double bending
Regulation
Shaping
1965
Float glas
glas
Float process
More com
larger
ape
Enamels
ceramics
Defrosting (coating)
1985
Free edges
Defrosting (wires)
Thin coating
1990
Athermic (on bended glad)
Antennas
Connections
Defrosting (thin coating)
Anti-rain
Revised durability tests
1998
Athermic (on PET)
Support to sensors (light, rain…)
Electronic
2001
Athermic (bendable)
Sekurit St Gobain Innovations fig 2