Organizing engineering / industrial design interface for innovation

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Lessons from the Renault "Design Fundamentals" process

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Abstract

This text relates an innovative process carried out jointly by Renault both engineering and industrial design departments, which has showed the possibility of a new form of cooperation, and drawn the outlines of a new model for the design / engineering interface organization. While being a form of rationalization of the design / engineering relationship within new logics of the car development process, this model also constitutes a framework for managing the development of innovative concepts, for other fields but design innovation. We propose the structuring of this model using the "design objects" notion and the organization of "pre-exploration spaces".

INTRODUCTION

Industrial design has still been very little studied. (Most of the works are in history[1], while in management they are most of the time sparse texts from researchers in different fields like marketing or innovation management[2]). However, a renewed attention to industrial design can be justified today, considering the importance of innovation in the competition and the recent focus on product development processes and organizations :

- designers are bearers of a part of the product value, for both the clients and the company. In an innovation competition context, design is a key factor regarding innovation, differentiation, esthetical qualities and symbolical meanings, products and brand identities[3].
- industrial design departments are involved in the important current transformations of the product development processes and organizations (project management, concurrent engineering, strategies of standardization, costs and waiting time reductions, etc.). How do these changes impact on design activities and organization ? How does the design participate to these changes ? During our three years at Renault, were carried out several actions and groups working on these questions : how to coordinate design and engineering processes, or to improve the design / engineering interface ? And this is still going on now, proving the importance of these issues for the company.
- last, recent studies on design and innovation management, especially by the CGS[4], allowed to build up a theoretical framework that can be used to address the industrial design activity, and the design / engineering relationship. (The analysis focusing on concept and knowledge dynamics in design processes, and on the coordination forms that support those dynamics (Hatchuel and Weil, 1999 ; Hatchuel and al. , 2001)).

These reflections justified our interest for studying the design / engineering interface organization at Renault, following a three-year “intervention-research” process, while taking a part into several projects and activities. Thus, the object of this paper will be to relate a specific two-year long innovative action led jointly by both engineering and design departments, called the Renault “Design Fundamentals” process, that resulted into the appearing of a new form of design / engineering cooperation. On the one hand, this action can be seen as a form of rationalization of the design / engineering interface, in order to combine new logics in projects management with design innovation. But on the other hand, being what we propose to focus on and retain, it finally showed how to organize collective design action for the development of innovative concepts. On that point, the analysis of the “Design Fundamentals” workgroups processes allowed us to see that for certain innovative concepts, the action cannot be engaged immediately in the existing frameworks (upstream innovation process, research activities, vehicle projects…), but that a preliminary work has to be done.

[1] See Dilnot, 1989 ; Margolin, 1989 ; Laurent, 1999 for a panorama.
[2] Among these : Fujimoto, 1991 ; Hayes, 1990 ; Lorenz, 1986 ; Hetzel, 1997.
[3] This is particularly true in car industry, where a survey by Renault showed that car design was one of the firsts criteria for the clients.
[4] Management Science Center, Ecole des Mines de Paris.

Hence, the main object of this paper is to propose some managerial elements, for the structuring of such processes. We build up a typology of what we called “design compromises prerequisites”, that have to be established for the accomplishment of the concepts developments in vehicle projects. To establish these “prerequisites”, the action has to deal with knowledge, coordination forms, and concept comprehension and specification. Then we propose the notion of “design object”, as an appropriate category for organizing design innovations, allowing to manage jointly all of these dimensions attached to a concept (knowledge, coordination, etc.). Last, we suggest the creation of “pre-exploration spaces”, which appears as a new kind of specific framework permitting to carry out the preliminary work and organize the continuation of the deployment within the other existing frameworks.

At the end of the paper, we formulate the hypothesis that this type of situation does not exclusively characterize industrial design innovations and the design / engineering relationship, but also corresponds to certain innovation situations in other fields, when the formulation of a new concept does not allow immediate action (because it requires the involvement and coordination of different competencies, the definition of new action forms and frames, etc.). Then the characterization and the managerial elements proposed appears of interest for this kind of situations : for organizing action for the development of innovative concepts.

After having described the current design / engineering interface organization, while underlining some of specificities of the design / engineering relationship (I.), we shall try to explain why this model currently encounters some difficulties, due on one side to the industrial design activity evolutions, and on another side to the recent changes in the product development process (II.). Particularly, the strengthening of strains in project management, and the opening of new upstream innovation spaces, pose specific problems for the design / engineering coordination. Lastly, we shall describe the “Design Fundamentals” process and the new design / engineering coordination model we derived from it (III.).

I. THE DESIGN / ENGINEERING INTERFACE CURRENT ORGANIZATION

1. The car development process : a “compromises building” process

The product development process has been described several times as a compromises building one (Moisdon and Weil, 1995 ; Aggeri and Hatchuel, 1997 ; Segrestin and al. , 2001). According to that view, it consists in building compromises between several *prescriptions* worked out by the parties involved (marketing, purchasing, engineering departments, etc.). This point of view can be adopted to tackle the description of the design / engineering interface. Design and engineering interactions throughout the project aim at building a “compatibility” between the design proposals (regarding the body and cockpit shapes, colors and trims, etc.), and the other prescriptions (specifications, standards, strains, etc.). For some of their aspects, design proposals doesn’t pose any problem ; for some others, they do. From there, for the second ones, new solutions has to be carried out (which

can require technical explorations), or some prescriptions, including the design proposals, to be revised.

Within that functioning can be found some characteristics already mentioned in several descriptions of the design process, focusing on other issues and participants[5] (role of agents proper strategies, difficulty in solving problems dealing with several vehicle parts and organizational divisions, etc.). The product and organization complexities explaining the now well known "three years necessary to design the last five millimeters"[6]. However, the design / engineering interface has got some determining specificities that have to be underlined.

2. Three specificities of the design / engineering interface

a. Design proposals are worked out during the projects

First, projects are the framework in which the design elaborates its proposals. Designers start drawing and shaping the models at the beginning of a project. They work on a *complete* vehicle, each time considered as *unique* and *new*, designed *for specific users and uses*. To begin, they need a product definition from the marketing[7], and some first specifications provided by engineers (the main vehicle dimensions, for example). This functioning - we shall come back to that point further - differs from recent new orientations in project management, which tend to require that every objective and specification could be given to each of the engineering divisions at the starting of the project (allowing inter-divisional contracts management)[8]. Regarding the design / engineering coordination, this functioning has several consequences, among which the following are two of the most important. It makes difficult the organization of an inter-project capitalization and of out of cycle explorations ; and above all, it makes the project framework being the quasi only place for explorations and learning, the quasi only design framework. As proposals are elaborated throughout the projects, there appear the problems, the missing knowledge and the technical explorations to be carried out.

b. Design and engineering work on different vehicle perimeters

As a second specificity, the vehicle perimeters considered by design – what we will call its "design objects" – do not correspond to the technical perimeters and organizational divisions of the engineering. When designers modify a "line" in the body shape, several "zone architects" and technical specialties from the engineering must be involved ; to get the same color on several parts in the cockpit, "color and trims designers" have to coordinate the work of different suppliers. This difference makes that the problems generated by the design proposals are most of the time, for engineers, "interface problems" : they impact on several technical zones of the vehicle, and one engineering division cannot solve them alone, but has to establish a coordination with other divisions involved. As a consequence, "interface problems" are for engineering among the most complicated to solve, and hence among the last to be treated (Moisdon and Weil, 1995). This situation does not only

[5] Moisdon and Weil, 1995 ; Aggeri and Hatchuel, 1997.
[6] Moisdon and Weil, 1995.
[7] As S. Dubuisson and A. Hennion already mentioned it (Dubuisson and Hennion, 1996)
[8] See Nakhla and Soler, 1998 ; Segrestin and al. , 2001.

characterizes the design / engineering relationship, but also every “transverse functionalities” (like comfort or safety, for instance). Their deployment has to be managed in specific ways : identifying the participants to involve, organizing their coordination considering the functionalities, etc. For most of those transverse functionalities, some repetitive processes can be implemented. But for the design, the fact to consider each project as new and unique, and to carry out the proposals during the project, make these stability and repetitiveness difficult. New relationships and processes relating to specific issues generally has to be carried out for each new project[9].

c. “Comprehension” and delegation of the design prescription

Last, considering the design / engineering coordination, a particular attention has to be paid to the comprehension and delegation issues (more than when dealing with engineering inter-divisional coordination problems, for instance). Designers and engineers speak different languages : they use different words to describe the vehicle, different techniques to depict it, and their action logics also differ[10]. Nevertheless, for design prescription to be taken into consideration by engineers, it has to be perceptible and understandable to them ; it has to allow them to act, within their own logic and processes[11]. In the design / engineering relationship, the comprehension issue must be considered at two different moment in the process : the original prescription – the design proposals - have to be perceptible and understandable ; but also, its modifications throughout the whole project process. When a proposal has to be modified, how to ensure that the modification will still fit with the original intent or concept of the proposal[12] ? If a painting supplier cannot get the exact red color demanded by a designer, what other red shade or other color is he going to develop ? How to determine new directions to explore ? One of the specific problems regarding the design prescription is that, because it relates to esthetics and it is personally attached to a defined person, it can hardly be delegated[13]. When a proposal has to be altered in order to become “feasible”, and that this modification cannot be carried out by the designer, by his own, because its feasibility depends on the engineers knowledge and possibilities, the engineers need some indications. The designer must make the engineer understand his “intention” or his “design principles”, in order to direct new explorations. A first mean for that lies in designer / engineer “face-to-face interactions” : only the designer is able to judge that the answer given by engineers is in keeping with his proposal ; only the designer is able to make the engineer understand his design principles and to find with him directions for a new solution, by verbal interaction (usually supported by sketches, models, etc.). An other mean would consist in formalizing the design prescription in a way allowing the engineers to “understand” its rules and to know when a solution fit with it, or does not.

[9] Designers usually consider that they have a “global” or “synthetic” “vision” of the product, and oppose it to a supposed “analytic approach” attributed to the engineers. (This view allows T. Fujimoto to see the “designer as an integrator” (Fujimoto, 1991), key role for projects management.) We could also pick out that design innovations are most of the time “architectural innovations” (Henderson and Clark, 1990), generating changes of “dominant designs” (Utterback, 1984). Renault Twingo or Scenic perfectly illustrate that point in car design.
[10] This is linked to the previous point : differences between their « design objects ».
[11] F. Aggeri and A. Hatchuel had previously underlined, studying the creation of a new expertise on vehicle recycling at Renault, that the more a prescription was easily understandable for engineers, the more its treatment was favored (Aggeri and Hatchuel, 1997).
[12] This issue has been adressed by D. A. Schön : in a collective design processn the coherence of the result depends on the comprehension of each participant design rules (or intents) by the others (Schön, 1997).
[13] This difficulty is also an internal management problem within the design department.

3. A coordination based on mock-ups and face-to-face interactions

a. The design / engineering interface organization

It is not possible here to give a complete description of how the design / engineering interface is organized, but we can note that it is based on two main pillars : mock-ups (clay models or "digital mock-ups") and, precisely, face to face interactions.

Exterior and interior design[14] almost follow the same logic : the process is designed as a research exploration. First, several roughs are proposed by about fifteen designers, competing for each project. Then a few small-scale clay models are realized, and then two or three real-scale ones are shaped. The continuation of the process consists in working with the engineers, and to converge toward the choice of one of the proposals that will finally be selected. Clay mock-ups are digitalized, providing CAD plans and models to the engineers. Mock-ups are therefore a first coordination tool for the proposals to be taken into account. After that, the building of the design / engineering compromises is allowed by face to face interactions within regular meetings, at different hierarchical levels. These meetings often take place close to the models, that aid the discussions. Specific meetings and informal encounters are organized in order to deal with issues specific to the project[15]. For the design department, design / engineering coordination is looked after by the managers, and designers themselves do not take part in the meetings. It is considered that their role is only to create the proposals, while being innovative. One of the problems is that design managers, being a very few of them, can hardly look after every issue.

The logic for "colors and trims designers" is a bit different. The parts they work on are developed by several suppliers (seats, dashboard, textiles, painting). Here, models are the colors and materials samples they give to the suppliers. Then their job mainly consists in managing explorations and developments carried out by these suppliers, whose most of them have got their own internal design department. Renault colors and trims designers take part themselves in the coordination with suppliers and the corresponding Renault engineering divisions. They are kind of "creation directors" or "art directors", giving directions to the suppliers.

Last, a fourth DDI[16] department is the team working on the cockpit arrangement or architecture. They do not deal with esthetical issues, but with the uses, functionalities, fitness of the cockpit and its internal fittings[17]. Here the proposals are formalized by models showing out the principles of the ideas or concepts, not an accomplished shape or part[18]. The relationship with engineering differs once again. The models only show a concept, so that engineering could understand the intent ; designing the accomplished shape and solution has to be done throughout a common work with engineers.

[14] That were previously called « styling ».
[15] This functioning corresponds to Mintzberg adhocratic structure (Mintzberg, 1978, as Moisdon and Weil already noted while studying coordination between engineering divisions (Moisdon and Weil, 1995).
[16] « Direction du Design Industriel »,Renault Industrial Design Department.
[17] This activity fits in with « industrial design » or « product design », and justifies that the « design » designation replaced the previous « styling » for Renault design department.
[18] For example, a model representing the idea of a « U shape » handbrake making up a storage space, for the new Megane.

Designers in this activity make every effort to participate in every meeting and involve the engineers when needed for development of the concepts.

Considering these different processes, a remark can be made. We may distinguish between two visions of the design / engineering relationship : some designers can consider that coordinating with engineers is not part of their work (it is needed only when engineers are not able to realize the proposal ; that they could do it would be the ideal situation) ; some can think, on the contrary, that their proposals cannot be carried out without working together with engineers, and that this cooperation is fully part of their job.

b. Some functioning conditions

Considering the mentioned specificities of the design prescription (carried out throughout the projects ; generating interface problems for engineering ; renewed at each project ; posing comprehension problems), a good functioning of this organization would require some conditions. It would notably imply :

- that in a project engineering has got all of the knowledge required to develop satisfying solutions to the design proposals ;
- if not, that engineering could create this knowledge (by carrying out explorations, etc.) during the project ;
- that every participants needed could be involved and coordinated in the project framework, in order to develop solutions to new problems specific to the project ;
- last, that design / engineering face-to-face interactions could be possible with every participant (those to be involved to address an issue, and those whose the action could impact on the design proposals).

II. A MODEL THAT ENCOUNTERS SOME DIFFICULTIES

The design / engineering coordination model that we have briefly described seems to encounter today some difficulties. If we cannot be exhaustive here, we can mention several elements that are posing problems, considering the description we made. First, the design activity and organization today has changed since the firsts designers have been integrated by Renault, and the design / engineering model implemented. Even if it has of course been amended, it does not really fit with the today design functioning any more. Second, the large transformations of the car development process carried out during the last fifteen years, especially the new approaches in project management, and the new structuring of the innovation process, also put the current design / engineering coordination model in trouble.

1. The building up of the design department

a. From sparse consultant designers, to an integrate design department

It is usually considered that car design consists in the designing of shapes and colors, for the body and the cockpit ; and these two fields – exterior and interior - actually were the firsts of “car styling”. But the firsts designers recruited by Renault, at the end of the 50’s, were not integrated into a department. A consultant designer were hired by the body engineering division ; another one were called by the marketing department, to help the suppliers in the design of textiles and cockpit parts. Each one of them was intervened on specific perimeters of the vehicle, and was a specialist in his own field (body designing, and textile creation), with a large technical knowledge in his field.

This relationship between design and technical competencies was close to the one in craft industry : designers were kind of experts within the engineering divisions ; esthetical and technical design competencies, for a perimeter or a group of parts of the vehicle, were almost integrated. It is allowed to think that the interactions between designers and engineers were made easier : by physical closeness, and common knowledge and languages, due to the designers specialization and to designers and engineers belonging to the same division. But the situation is quite different now :

- the different design activities have been integrated into a unique design department, that progressively became an autonomous entity (reporting directly to the Renault CEO since 1988) ;
- during the same period, designers became more general practitioners (a designer today works indifferently on the exterior and the interior). Their skill lies more in their drawing ability and in their “creativeness” than in their product or technical familiarity.

These evolutions, that resulted into a separation between design and engineering competencies, have made the interactions both more difficult and more necessary at the same time, the participants being physically separated, and the technical competencies of the designers being not considered any more as an important one.

b. Innovation as a design rule

At the same time, the vision of the design activity progressively changed[19]. A vision of industrial design as specific approach for designing, or thinking of products in all their dimensions, replaced the vision of the “stylist” intervening exclusively on esthetical issues. As a matter of fact, car designers at Renault don’t work exclusively on the shapes and colors any more, but also on other dimensions of the vehicle[20]. More, they renew themselves their own fields of intervention, and within each field, their design principles, according to a proper logic[21].

[19] To come to fit with the common vision of « industrial design » in the other industries. This period is the one of the structuring of the industrial design profession.
[20] In that sense, industrial design innovation can be something else but « shape innovation » (Vervaeke, 2001).
[21] The logic of trends in product design, architecture, visual arts, etc., conveyed by exhibitions, journals, etc.

This evolution is true for industrial design in every fields. The designers at Renault who work on the uses and architecture of the cockpit are an example of it. The “colors and trims” designers now intervene on touch, or on light in the cockpit. And the “Design Fundamentals”, as we shall see, also show this evolution. Within each of those fields, the design principles are regularly renewed : regarding the body shape, “edge design” has recently replaced “bio design” ; and the brand new Renault concept of “touch design” tells a new attention to touch and ergonomic dimensions.

This capability for renewing itself its own intervention fields and rules (or concepts), according to a proper logic, is for sure the source of the value that design brings to the products and to the company. But it also makes that the technical fields, vehicle perimeters, engineering experts, with who designers have to work, are on one side more numerous (they’re not only the body and cockpit shapes experts), and on another side each time new (at each new field designated, and each new design principle). Moreover, clay and digital models will not necessarily be the most appropriate tool to work on these new fields (how to organize the design / engineering coordination to explore “sound design” or “light design” ?).

2. The new logics of the car development process

a. New approaches in projects management restrain explorations possibilities

What we have just tried to show is that, when considering the evolutions of the design activity on a long period, the current organization of the design / engineering interface - that for its main lines dates back to the firsts designers recruited by Renault – is not the most adequate to what the design activity has became today. More recently, several important changes in the organization of the car development processes also came to pose problems to the design / engineering interface.

The organization of the car development process has of course, for different reasons, become more complex, and the participants involved more numerous, making the face to face interactions more difficult[22]. But more precisely, the transformations resulted into a twin logic : the strengthening of strains in the projects framework, and to compensate it, the creation of new upstream innovation spaces.

Some new strategies in the design process management, aiming for most of them at reducing the design costs, generate the consequence that an important number of choices and decisions which were previously made during the projects are now pre-determined before. Standardization strategies for economies of scale are among them. Purchasing strategies (components carry-over or carry across, long term agreements with suppliers, structuring of the suppliers panel) has for consequence to pre-determine the choice or possibilities of using of certain components or technologies. Multi-projects management or platform strategy also largely determine in advance key properties of the different projects linked, or bodies that will share the same platform, and make necessary to amend the development processes. On a different way, modules strategies require that the vehicle

[22] Between 1964 (development of the Renault R16) and now, the engineering staff has increased from 600 persons to 6 000.

architecture and zoning are fixed at the beginning of the projects, making difficult the development of conceptual or architectural innovations in the project time[23]. Last, recent efforts of formalization in projects management (internal contracts[24], indicators, functionalities deployment management, etc.), aiming at improving the projects performances on key issues (cost and waiting time reduction, quality, safety, etc.) has another effect for design : it makes that engineers are more incited to consider prescriptions relating to these issues, than the design prescriptions which, are less formalized.

b. Participating into upstream innovation activities

To compensate for the reduction of the learning or exploration possibilities throughout the projects, new approaches in project management were completed by the "opening" of new upstream innovation spaces. This new logic finally appears as operating a moving of the learning spaces, from the projects framework, to new upstream frameworks.

At Renault, adopting this logic has been one of the main directions of a large reorganization of the engineering department, engaged in 1999. The objective was to organize the upstream "preparation" of innovations, in order to be able to "transfer" it to the vehicle projects. It resulted in the structuring of a new innovation process, allowing to manage innovation from long term research directions, to short term innovations for the projects and innovation politics for each of the engineering divisions, which is still being implemented.

As these upstream frameworks are now the place for learning and explorations activities, it is there that prescriptions for the development of innovative concepts have to be "given", to be taken into consideration. If some innovative ideas brought by design require long term explorations, or the involvement of new specific participants, it is there that they must be formulated. Then a question appears that the design has to face : how to take part in these new functioning ? on what kind of "object" may action be organized, in these upstream spaces ? This question poses two problems for the design :

- **Working without any product definition.** As said above, designers use to start working in a project considering a definition given by the marketing. They design a vehicle for specific clients and uses, including some defined technical properties. The ideas they propose strongly depends on these product definition, target clients and uses, and each vehicle is seen as specific, new and unique. So how to proceed to define design concepts or directions without any relation to a specific project, without considering specific clients and uses, and that could be common to several projects ?
- **Working on "incomplete" vehicles.** Secondly, designers usually draw "complete" vehicles, on the one hand for the reason that we have just mentioned (they design a specific product for defined clients and uses), on the other hand because the vehicle perimeters on which they intervene differ from the engineering divisions ones. The complete body shape, the colors and materials for a complete cockpit, the cockpit habitability, etc., are different dimensions of the vehicle which impact

[23] See Segrestin and al. , 2001.
[24] See Nakhla and Soler, 1998.

on several technical, zones, parts and engineering competencies. But the explorations or other processes in these upstream activities usually focus on technical zones or components, or on technical knowledge fields (materials, electronics, etc.), or on some functionalities fields (comfort, security, etc.). How to organize the design participation to these explorations of vehicle parts ? How to establish a relation between the design "design objects" and the ones of these upstream activities ? How can the design determine some directions to explore within these frameworks ?

III. RENAULT « DESIGN FUNDAMENTALS » : A NEW DESIGN / ENGINEERING INTERFACE MODEL FOR THE DEVELOPMENT OF NEW CONCEPTS ?

1. The "Design Fundamentals" process

We're now standing at the point which is the main object of this paper : the possibility of a new form of design / engineering cooperation opened by the "Design Fundamentals" action. If this action has not clearly been engaged after a formal analysis of the design / engineering interface problems, it aimed nevertheless at bringing new answers to some difficulties encountered by design, when trying to reach certain objective or develop certain innovative concepts. It is allowed to say that, from this point of view, the "Design Fundamentals" process was engaged to find a solution to conciliate innovation with the new project management approaches, regarding the design / engineering interface. We have to mention here that several other actions were in hand at the same time, engaged by C. Ghosn, within the engineering, purchasing and production organizations, for improving their performances on several issues.

The "Design Fundamentals" process started by the formalization, by the design department, of a set of "design principles" supposed to be adopted for all of the projects. These principles were of different kinds : some of them were clearly defined or specified objectives that design didn't managed to reach (for example : "make wings flush with wheels", or "shorten the overhangs") ; some other ones were kind of general or abstract concepts, designating new design fields or directions to explore (for instance : "magic of the dashboard panels", or "looking for light in the cockpit"). This set of principles dealt with all of the design fields : exterior, interior, colors and trims, uses and architecture, engine compartment design. At first, they had been committed to a little handbook distributed to the other departments (engineering, marketing, purchasing, etc.), and presentation sessions were organized. Then, the vice-presidency in charge of the engineering and the design department jointly decided to create several temporary transverse workgroups, to determine the means of progressing on these principles – reaching the specified objectives, developing the innovative concepts. About twenty subjects were defined from the "fundamentals", among which seven had been treated by the workgroups.

2. The workgroups processes and results

a. The example of the "light in the cockpit" workgroup

To make the lecturer understand the work done by the groups, we shall relate here some elements of the process followed by the group who worked on the subject "Looking for light in the cockpit". First, the two leaders of the group –one engineer and one designer – called to a first meeting the participants who should be involved to work on this subject, from their own viewpoint and comprehension of the subject. They convened an engineering architect, an ergonomist, a manager of the "comfort" functionality at the marketing department, a lighting equipment engineer, and two designers. We can remark that while doing that, the group leaders already determined a first "definition" of the concept and some first directions for its realization.

Then the two or three following meetings aimed at précising the definition – or comprehension – of the concept, and planning a work process for the group. They dealt with questions as : what were the design intents when formulating this subject ? What are its expectations relating to this subject ? What kind of concrete answers in the projects may be foreseen, and what ways and means may lead to it ? This first step in the group process resulted into the consideration that interior light was depending on : the vehicle architecture (especially the quantity and layout of window panes) ; the lighting equipment ; and the "masses, shapes, colors and materials of the cockpit". After that, the work was divided into three subgroups focusing on each of these three sub-themes. Each subgroup followed a specific process, and convened new participants.

The group working on the lighting equipment draw the outlines of several directions that could be explored : work on light colors, use optical fibers technology, make the lighting "magic", use the lighting to shed light on innovations or on the cockpit design, or make a Renault car recognizable by its interior light, etc. They organized internal survey, convening a panel of about fifty Renault participants from different departments, around fifteen vehicles (Renault, competitors, research prototypes), on the subject : "perception of the interior light", in order to get new tracks and sort out the ones to explore. This led the group to propose a redefinition of the lighting functionality (including new atmosphere, design, brand identity dimensions), and the structuring of a road map for lighting engineering division.

The subgroup dealing with the architecture theme defined new technical criteria to be considered by engineers, relating to the window panes, in order to manage the effects of architectural choices on the cockpit light (for instance : rate of window surface against total body surface). They realized measurements of several vehicles to validate the criteria, and proposed to integrate them to the formalized processes of both body and architecture engineering divisions and to design ones.

Last, the work done on the cockpit "masses, shapes, colors and materials" resulted in some amendments of the "colors and trims design" process (for example, the cockpit colors until there were judged under natural light, not under the real cockpit light depending on the windows colors and on

the lighting equipment). It also led to the proposal of new concepts to explore, among which the idea of a “thin seat”, to improve the overall vision, the visibility, and the communication between passengers in the cockpit. Finally, the group leaders of the work done on the “light” subject proposed to the managers the definition of a “Renault brand politic” regarding the “cockpit light”, and the carrying out of the actions proposed (innovation directions to explore, processes to amend, etc.).

b. A three-stage process

What of this can be remembered ? How to characterize this work ? Finally, what the groups have done is to organize the action for the development or realization of the concepts and objectives formulated by the design ; to make this action possible. If the processes followed by the groups were all different, they share common elements and it is possible to characterize a generic process. The work done on the “light” subject is almost representative of what has been done by the others. First, we can note that they followed a three-step process :

1. At first, the leaders and the firsts participants recruited realize a first step in the specification of the concepts. Using up their own knowledge, they carry out a first set of directions to explore in order to make the concept concrete. They identify the competencies that must be involved, and determine some actions or processes to engage for the continuation of the work. (Let remark that these three processes – specifying the concept, identifying competencies, and determining action to be ran – are simultaneous. To say that light depends on the lighting equipment, is at the same time to designate lighting engineers as having to be involved, and to determine that the actions will have to be continued within the action logic and frameworks of these participants.)
2. As a second step, to carry on the work, participants of the “first circle” have to mobilize again some new ones, and/or to engage actions : their own knowledge is not sufficient to go further ; they have to mobilize, acquire or create new knowledge, they have to “learn” about the concept or the firsts directions they defined, to be able to go on. “Design Fundamentals” groups thus engaged several kinds of actions : measurements to validate new engineering criteria, internal “client survey” on “light perception” to learn from the “clients” the directions to explore, building of technical critical paths in order to identify technical ways of progress, etc. From case to case, they had to learn on different objects : product itself, internal organization, competitors, clients (value of directions to explore seen by the clients ; new directions formulated by the clients[25]), technical issues, etc. The actions had to be feasible in the framework of the groups ; they had been different according to the subjects.)
3. Third, after the concept specification and the learning accomplished in the two first phases, the groups determined :

    - actions to be ran in other frameworks in order to continue the concept specification and the explorations (upstream innovation process, projects) ;
    - the organizational conditions to establish for these actions to be engaged and lead to concrete results in the projects.

[25] Who here becomes a designer…

c. The group results

The work done on the "light" subject is also representative of the results of the seven groups ; these results deal with two dimension : knowledge, and coordination :

- regarding the knowledge, we have seen that they had ran action to create knowledge on different dimensions. Among their results, they identified technical solutions immediately available and usable in the projects to reach the objectives, and explorations to be engaged for the development and validation of innovative directions.
- regarding coordination, they made some organizational cartographies, redefined or created certain processes, or proposed new forms of cooperation between divisions, or between Renault and some suppliers (for example, a new Renault / Valeo innovation process was proposed in order to innovate on headlights). Last, the new engineering criteria created for several subjects (among which the architecture criteria relating to the daylight in the cockpit), also constitute new design / engineering coordination tools.

Moreover, it can be considered that they also deal with another issue : the comprehension. One of the groups results has been to make the "design objects" of the design, "**common design objects**" – common to the participants needed for their deployment, i.e. allowing the action of each of them. This constituting of "common design objects" has been made in different ways :

- by creating new ways of representing or formalizing the concept : for example, the building of technical criteria, providing new parameters to be considered by the engineering. (This correspond to an expansion of the "conceptual language" for the product description[26] ; like speed, for example, that can be characterized in "mph" and measured with specific instruments, the flushing of wings with wheels can be measured.)
- by associating already existing "engineering design objects" to the design concepts : for instance, when identifying the optical fiber technology as a direction for creating a "magic light".
- last, by a joint creation of new objects : the work done on the light, for example, exceeding the original definition and expectations of the design, led in a way the creation of a new "light" object at Renault.

d. The "compromises prerequisites"

We can now precise our view of the groups work and results. To get back to our previous vision of the design process as a compromises building one, we can consider that the "Design Fundamentals" groups finally showed the existing of "compromises prerequisites". The considering of all the seven groups allow us to structure a more precise typology of these "prerequisites".

a. concept maturity. To engage a collective action in order to develop a new concept, this concept has to be "mature" enough. One of the actors, at least, must have enough "knowledge" or ideas

[26] Pahl and Beitz, 1984.

on the concept, for being able to decide if the ideas or directions proposed by the group really fit with the original intention. If this maturity misses, the reflection to define directions to develop may rapidly stop. (For example, a group working on “the magic of dashboard display panels” could hardly structure a working process, the design participant being unable to tell enough things on the concept, for the other to act. Concept maturity can be achieved by the group, or require further work from the design by its own).

b. **knowledge availability.** On a similar way, reaching a compromise implies that the knowledge needed for solutions is “available”. Creating or acquiring this knowledge (technical one, or knowledge on the client or on concurrence, etc.) may require long time explorations or other actions that can hardly take place in the projects strained framework. (Developing the “thin seat” requires long term learning actions to be carried out jointly with suppliers.)
c. **action framework adequacy.** The action organizational framework has to allow the carrying out of the actions needed for learning (technical explorations or others), and the using of identified solutions in vehicle projects. For that, adjustments or modifications of the organizational framework may sometimes be necessary. (One of the results of the group working on “making wheels flush with wings”, for instance, was to suggest a lobbying action by Renault, aiming UTAC to modify his standards in order to allow French car makers to use the same solutions as the German ones.)
d. **inter-comprehension on the concept.** Maturity of the concept is a prerequisite. But to ensure that its final forms in vehicles will be in keeping with the original idea, the knowing and comprehension of the concept by all the actors involved and able to have influence on the compromise, is another one. To this end, the elaboration by the groups of new way of representing design prescription (by technical parameters for example), or the definition of new design processes associated to specific issues, had been a mean to favor the elaboration of solutions in accordance with the original concept. (To give a counter-example, the “U shape” parking brake of the new Renault Megane was supposed to be a storage space ; successive modifications, during the design process, made that it finally lost the primary idea, while keeping its shape.)
e. **inter-compréhension on processes.** Reaching a satisfying compromise, regarding the original concept, requires to take into consideration the action processes of all the actors involved (their action logic, organization, formalized processes). The work done by the groups permitted here to know and understand these processes, and when it appeared necessary, to modify them. (One group, for instance, defined a new specific process in order to be able to develop innovative headlights, including upstream partnership with the supplier.)
f. **actors identification.** Last, to build a satisfying compromise it is necessary to identify all of the actors to involve : those needed for learning and explorations, and those whose action in the project process can affect the compromise. In a complex organization, this may require specific actions (J.-C. Moisdon and B. Weil have talked about “inquiries” ; (Moisdon and Weil, 1995)). The work done by the groups permitted to build this pre-condition, by specifying concepts, and defining new processes or coordination forms. Here, an important point has to be underlined. The search for actors to involve may lead to the identification of “missing actors”, of needed knowledge without any existing actor associated in the firm. Then, building the “actors identification” prerequisite amounts to spotting new expertise, functions or relationships to create,

and relates to the management of competencies[27]. (The work done on the "light in the cockpit", for instance, which led to define "light" as resulting of the windows, the lighting equipment, and the colors and shapes of the cockpit, may lead to the creation of a new "light" expertise / function at the engineering department, "light" becoming a design object at Renault, as it is for example in theater or in movie making (where "lighting technician" is constituted profession, where a specific language does exist by which the director describes the kind of light he wants, permitting the light technician to "act" within his own process[28].)

These "compromises prerequisites" draw on different types of actions that had to be carried out, before a compromise could be reached. It shows us the kinds of actions that has to be engaged in order to develop design innovative concepts. It is allowed to think that these actions correspond to what was previously made in interpersonal relations between designers and engineers, when the development process allowed it, and can hardly be made within the new frameworks. Rather than a formal process, these "compromises prerequisites" indicates several dimensions of action, to be taken into account. Hence, the issue we can consider now is : what are the organizational conditions allowing to establish these prerequisites ? What are the organizational frameworks in which prerequisites can be established ? The "Design Fundamental" process can be seen as an experimental framework for this kind process, but the analysis we made provides us with more precise elements to better organize them.

3. Managerial elements for a new design / engineering interface model

We can finally better express what has been the function of the "Design Fundamentals" workgroups : they organized the action for the deployment of innovative design concepts, in order that it could be engaged in the existing organizational frameworks (upstream activities, projects, etc.), with modifying these frameworks when needed. To do that, the groups themselves "initiated" the action : the specifying of concepts, and the learning. They carried out a "pre-exploration" of the concepts, in order to make the continuation possible in the existing learning spaces. In return, we can propose two managerial elements for the management of these processes.

a. "Design objects" : an appropriate category for organizing design innovation

One of the groups results is to have made the design concepts become common "design objects", allowing action of all the participants involved. As seen, we can consider that a "design object" is an innovative concept, to which the work done by the group has permitted to associate identified competencies, available solutions, explorations to engage, specific coordination processes and tools, specific forms of action. This notion of "design object" then appears as an appropriate category to organize design innovation : to manage the deployment of a "design object" means to manage jointly the knowledge, learning actions, coordination forms, and "sub-objects" attached to an innovative concept. It is to have for each innovative concept a cartography of the participants involved, of the

[27] P. Le Masson and B. Weil talk of "competencies embryology" (Le Masson and al. , 2001).
[28] Speaking with the director, he will rapidly know what kind of projector he's going to use, where to set it out, etc.

actions to be ran for the progress of learning and the completion in vehicle developments, of the coordination processes and tools to implement, and to manage the entire set.

This notion, which includes in itself the links between the objects of the projects framework (complete vehicles) and the ones of the upstream activities (components, technologies, etc.), and the design concepts, seems to be better fit with the design logic than other categories (like for example the one of “innovations lists”). Moreover, “design objects” being transverse both to the projects and the design internal divisions (exterior, interior, colors, etc.), this category allow to organize a both inter-projects and inter-design divisions capitalization and innovation deployment, which is missing today.

According to the “prerequisites” remaining to establish, it is possible to distinguish between four types of “design objects” :

- **known objects** : for these objects, all of the prerequisites are already established. They can be deployed while reaching the objectives without any specific action, within the usual projects process.
- **renewed objects** : for objects of this type, some prerequisites are still to be established, but it can be done within the projects framework by running specific actions, like short explorations or light amendments of the coordination systems. They can so be deployed during the projects, but their deployment has to be specifically managed. (Light innovations on “known objects” are among this category, like the “U shape” handbrake in the new Renault Megane).
- **new objects** : here, prerequisites remain to be established, but the work can not be done in the projects framework. It requires medium or long term explorations, important changes of the organization or of coordination modes, to be done out of the projects (for instance, exploring the “thin seat” innovation direction, or building a specific partnership with a supplier). But the formulation of the concept is clearly understandable, the object is mature enough to allow immediate action ; the action will focus on knowledge and coordination.
- **emerging objects** : objects in this last category are still kind of abstract concepts. To much little things are known about them, and their wording is not clear enough to allow immediate action in existing frameworks. Every prerequisites have to be built, particularly the “concept maturity”, which implies upstream actions. (Among the “Design Fundamentals” subjects, “magic of the dashboard panel” or “light in the cockpit” were “emerging objects”).

Distinguishing between these four types of “design object” is a mean to organize their evolutions and their renewal : “known objects” can have been previously “emerging” or “new” ones, but once the prerequisites have been established, their deployment is almost a routine. The categories that need what we shall now call a “pre-exploration” work (as done by the “Design Fundamentals” groups) are those of “emerging” and “new” objects. Hence, managing design innovation is to manage a “**design objects portfolio**” made of these four kinds of objects.

b. The "Design Fundamentals" groups as "pre-exploration spaces"

As we have now understood, "Design Fundamentals" groups showed the work having to be done to develop innovative design concepts, and that could not have been carried on within the other frameworks in the organization. Engaging action on innovative concepts requires a specific work to be gone through first (specifying the concepts, defining the competencies needed, the actions to run, the frameworks to do it, etc.). The "Design Fundamentals" workgroups, that permitted to establish the links between the design new concepts and the existing organizational frameworks (upstream innovation framework, and projects), allowed that work to be done. Then, it appears as a new type of learning or exploration space, that we can call "pre-exploration space".

Hence, we suggest that the categories and typologies we draw out could support the structuring of this new type of innovation space : the three-step process, the "compromise prerequisites" typology, the "design objects" could help the participants to define their actions.

Managing design innovation may finally consist in :

- structuring the "design objects portfolio", including its renewal dynamics ;
- managing the deployment of "known" and "renewed" objects in the projects ;
- managing the deployment of the "new" and "emerging" objects within "pre-exploration spaces" and when done, within upstream, project or other existing frameworks.

CONCLUSION

In this paper, we related a specific action carried out jointly by the Renault design and engineering departments, which led to the revealing of a possible new form of cooperation. Remembering our description of the design / engineering relationship specificities and of the problems encountered by the current design / engineering interface model, we can consider the new form of cooperation experimented throughout the "Design Fundamentals" process as a form of rationalization, due to difficulties generated by organizational changes, and aiming at combining new approaches in project management (to improve costs and waiting time reduction performances) and design innovation. The way we analyzed the "Design Fundamentals" process made us consider the issue as follow :

- the question the workgroup have faced is : how to organize the development of innovative concepts…
- … for which the competencies and participants to involve cannot be immediately identified, and are potentially several, and different…
- … and when action cannot be immediately engaged in the existing frameworks ?

The "Design Fundamentals" workgroups showed us that organizing action in this kind of situations, required to work on knowledge, coordination, concept comprehension and specification, in order to establish some "prerequisites" for the accomplishment in vehicle projects. For the structuring of such

processes, we proposed to retain the notion of “design objects” - permitting to manage with coherence actions on all of these dimensions -, and the one “pre-exploration space” - specific kind of design and learning space where to organize further action within the other existing frameworks (upstream activities, projects…). These approaches are still being experimented at Renault.

For the design, this model results in a more cooperative relationship with engineering, as common action can be engaged on the design principles or concepts, and not on “accomplished” models for engineers to “reproduce”. Within the new model, working with engineers is fully part of the designers work[29]. We think that this analysis, using a theoretical approach focusing on the dynamics of both design and engineering concepts, knowledge and coordination modes, provides us with a framework allowing to address design / engineering coordination issue in other contexts. Even if this issue in the car industry has strong specificities (complex product and organization, internal design department, with a particular history…), our view is that this framework may allow us to study thoroughly the cases of other companies, industries, and of the cooperation between firms and external consultant designers.

But this study also indicates two other questions that should be explored :

The first of it has already been mentioned. It the one of the interest that the “Design Fundamentals” analysis and the model derived from it may offer, for innovation management in other fields than design innovation. As said, to organize action for the development of an innovative concept, with the characteristics mentioned above, is a situation to be encountered in other fields that in design innovation. To create the “recyclable car” or the “communicating car” is not very different of working on “the magic of the cockpit lighting” ; they are all kind of “emerging design objects”. Studying the model interest and applicability in other innovation fields would be a first direction to explore.

The second direction is more theoretical. It can be considered that the issue we finally dealt with is : how to organize action on a new concept (or emerging question or “action object”) ? How is the coordination between participants created, seeing that their action logics, languages or forms of knowledge will for sure be different ? How new coordination between existing collectives do they modify the relations between them, and even generate new collectives ? To focus on the “inter-epistemic” dimension of collective action appears to us as an important issue in management science today, as innovation (not only product innovation, not only in industry) is developing, and as knowledge – fields of knowledge, and forms of knowledge – is rapidly renewing. What from our case may be derived regarding this point ? How do the existing management theories usually consider it and take - or not – into account the “inter-epistemic” issue ?

To sum up, we suggest that further research may : carry on the studies on industrial design in product development organization ; explore the interest of this analysis for the management of “emerging

[29] We cannot develop this remark here, but it refers to different models of relations between « esthetical designers » and « technical designers » that can be found in the history of the industry or in architecture history. What we call this « cooperative » form of relation is the one promoted by A. Loos for the cooperation between the decorator and the craftsman (see Loos, 1994), or the one described by P. Rice, that he as a civil engineer had to the architects he worked with (Rice, 1994).

design objects" in other fields ; last, address the "inter-epistemic" dimension of collective action, especially in design and innovation activities.

Bibliography

AGGERI F. AND HATCHUEL A., 1997, *Les instruments de l'apprentissage. Construction et diffusion d'une expertise recyclage dans la conception automobile*, in Moisdon J.-C. (eds.), *Du mode d'existence des outils de gestion*, Paris, Seli Arslan.

DILNOT C., 1989, *The State of Design History. Part I : Mapping the Field ; Part II : Problems and Possibilities*, in Margolin V. (eds.), *Design Discourse. History, theory, criticism*, Chicago - London, The University of Chicago Press.

DUBUISSON S. AND HENNION A., 1996, *L'objet dans l'usage : la relation objet - usage - usager dans le travail de trois agences*, Paris, Presses de l'Ecole des Mines de Paris.

FUJIMOTO T., 1991, *Product Integrity and the Role of Designer as Integrator*, in *Design Management Journal*, spring 1991.

HATCHUEL A. AND WEIL B., 1999, *Design Oriented Organizations. Towards a unified theory of design activities*, 6th IPDM Conference, Cambridge (UK), July 5-6 1999.

HATCHUEL A., LE MASSON P. AND WEIL B., 2001, *From R & D to R-I-D : Design strategies and the management of "Innovation Fields"*, 8th IPDM Conference, Enschede, The Netherlands, 2001.

HAYES R. H., 1990, *Design : Putting Class into "World Class"*, in *Design Management Journal*, 1, 2, summer 1990.

HENDERSON R. M. AND CLARK K. B., 1990, *Architectural Innovation : The Reconfiguration of Existing Product Technologies and the Failure of Established Firms*, in *Administrative Science Quarterly*, 35, March 1990.

HETZEL P., 1997, *La gestion des projets de design : déroulement des projets et modalités de fonctionnement*, in *Gestion 2000*, 13, 5, septembre - octobre 1997.

LAURENT S., 1999, *Chronologie du design*, Paris, Flammarion, 237 p.

LE MASSON P., HATCHUEL A. AND WEIL B., 2001, *Le co-développement à l'épreuve de l'innovation intensive : vers de nouvelles formes d'organisation de la conception innovante entre constructeurs et équipementiers*, in *Actes du GERPISA*, n°32, décembre 2001.

LOOS A., 1994, *Paroles dans le vide (1897-1900). Malgré tout (1900-1930)*, Paris, Editions Ivrea, 335 p.

LORENZ C., 1986, *Design Dimension*, Oxford - New-York, Blackwell, 167 p.

MARGOLIN V. (eds.), 1989, *Design Discourse. History, Theory, Criticism*, Chicago - London, The University of Chicago Press, 291 p.

MINTZBERG H., 1978, *The Structuring of Organizations : a Synthesis of the Research*, Prentice Hall.

MOISDON J.-C. AND WEIL B., 1995, *"Collective design : lack of communication or shortage of expertise ? Analysis of coordination in the development of new vehicles". Designs, networks and strategies, European Commission, pp.97-110.*

NAKHLA M. AND SOLER L.-G., 1998, *Project management and internal contracts*, in Lundin R. A. et Midler C. (eds.), Projects as arenas for renewal and learning processes, Boston (Ma.), Kluwer Academic Publishers.

PAHL G. AND BEITZ W., 1984, *Engineering Design : A Systematic Approach*, London, The Design Council.

RICE P., 1994, *An engineer imagines*, Artemis, 208 p.

SCHÖN D. A., 1997, *Apprentissage organisationnel et épistémologie de la pratique. Le jeu du silence vu comme une parabole de l'apprentissage organisationnel*, in Reynaud B. (eds.), *Les limites de la rationalité. Tome 2 : Les figures du collectif (colloque de Cerisy)*, Paris, La Découverte, pp.157-167.

SEGRESTIN B., LEFÈBVRE P. AND WEIL B., 2001, *The role of design regimes in the coordination of competencies and the conditions of inter-firms cooperation*, in *International Journal of Automotive Technology and Management*, vol. 1, n°2.

UTTERBACK J., 1984, *Mastering the Dynamics of Innovation*, Boston, Harvard Business School Press.

VERVAEKE M., 2001, *Le modèle de conception de l'innovation formelle,* Séminaire Franco-Allemand, janvier 2001.