Modellization of the car design process

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Abstract: Our research has taken part in a collaboration between a big European car supplier and the research laboratory in conception of new products (C.P.N./E.N.S.A.M PARIS). The subject was the definition of a method of design watch for the car suppliers, helping them in their development decisions.

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1 General Introduction

The conception of visible parts under the supervision of the car parts manufacturers fits into the trend where the different fields of work tend to become homogeneous on either side of organizations builder and parts manufacturer. However, the former deals with global conception whereas the latter works on the conception of subsets also known as systems. This homogenization of professions is at the beginning of an increasingly greater coherence between parts and the whole and mutually. We will see that it now comes into the profession of industrial design. The first motivation of

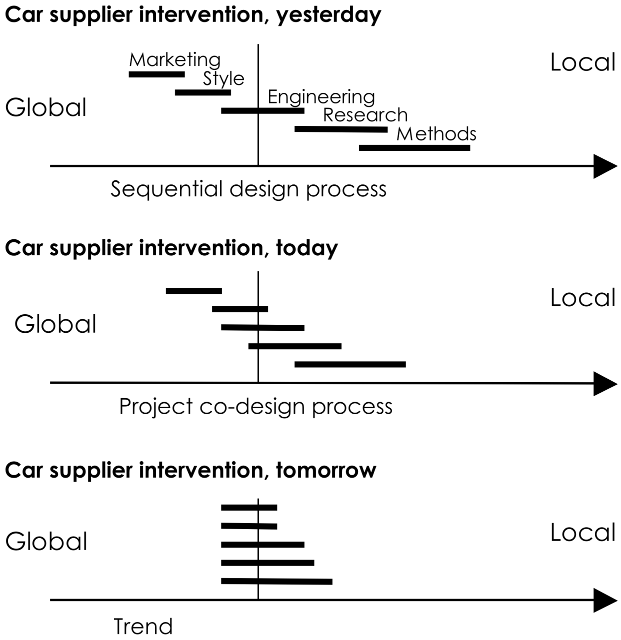

Figure 1 Evolution of professions among car builders and car parts manufacturers.

the companies is the reduction of costs and delays, and improvement of the quality at the same time.

2 Problem of the formal car co-conception

With regard to the conception of the visible parts, the car suppliers are dependent on the strategy of the car builders, hence an uncertainty on their part concerning the Formal evolutions of these parts, as well as the choices connected to their process. Some of them decided to anticipate the Formal[1] evolution of vehicles through observation in order to be able to propose technological innovations highlighted by partial Formal propositions. The process of Formal design in car design joins in a specific frame characterized by its economic and manager dimensions. MIDLER [1] illustrated them with the concepts of dynamic variety, obsolescence and the ability to react. The method which we proposed considers manager alterations associated with the activity of car co-conception which are:

- the evolution of the place of the parts manufacturer in the global process of conception
- the shortening of conception time

So, if the observation seemed necessary and sufficient at the beginning of our research, the function of help in the communication between the world of design at the builders, and that of technological innovation at the car suppliers, seemed to us to be just as important. Indeed, the conception time became shorter, and relations between the style departments at the builders, and engineering at the suppliers were therefore transformed. We proposed a method and tools so that the latter can achieve greater autonomy in its strategic decisions, while favouring the implementation of a partnership with the builders in the context of a learning co-organization based on the suggestion of local concepts in accordance with the global Shape of the vehicle. For this, we leaned on the hypothesis according to which the choices of industrialization or innovative technologies depend partially on the Formal characteristics of the visible constituent, the conception of which can be based together with a descriptive formalization of the global process of conception of the Shape, and a prescriptive formalization of the process of conception of the Shape of the visible constituent. Thus, we were first concerned with modelling the early process of conception of the Shape.

3 Modelization of the car design process

At first, the object of our research was to understand and formalize the process of car design, by proposing a model based on the conjunction of product – process points of view. We considered the process of design as the transformation of a problem space, either initial system of signs, in a solution space, or final system of signs. The diachronous design process is characterized by the global progressive reconfiguration of a space problem (brief) in a space solution (3-dimensional model), according to a recursive cycle in which a partial transformation takes place from the space problem to intermediate solution spaces at every representation level. The dynamics of the problem – solution couple amounts to the concept of functionality [2]. This partial transformation first occurs by way of the mental representation of the designers. It is followed by feedback for the evaluation.

At any time in the process, the designer must be able to assimilate and treat a large volume of information, without losing sight of his objectives. This equivalence characterizes the problem/solution space.

The design process consists of reducing abstraction through the use of various successive levels of representation integrating more and more constraints. It is characterized as a conceptualization including an iterative cycle of mental solutions shown with a given problem, when (1) the selection of a solution or partial solutions enables the reduction of uncertainty, keeping in mind the necessary level of vagueness in modifications during subsequent phases [3], (2) new constraints are then added by preserving shape and initial ideas, and (3) the display of a new physical representation is going to generate new ideas and new solutions.

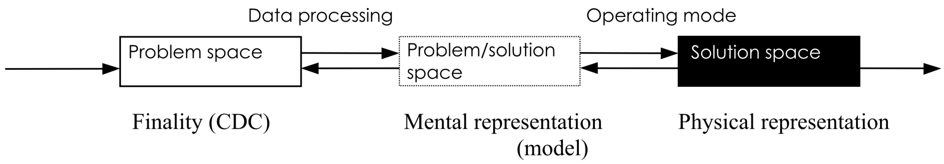

Figure 2 Description of a materialization cycle.

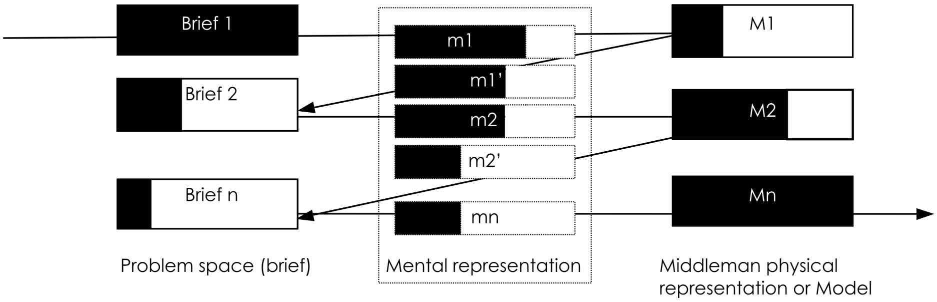

Figure 3 Representation of the design process (adapted from [3]).

Abstract finalized information is transformed step by step into material information, by way of mental representations (transfer of information: darkened part). The information is what forms or what transforms a representation. Here, one can make a comparison between the transformation of images and the representations generated by a message containing information. The information modifies the representations, so one can measure communication by measuring these changes. A physical system supplies an *external memory*, that modifies the problem of perception in a decisive way. The space problem (expressed goals) as well as the solution space (physical representations) are *punctually made explicit by the production of signs*, as with verbal codes in the case of the brief, and formal codes in the case of solutions. Each cycle *Brief1*, *m1*, *M1* corresponds to a state of representation. The evolution of the Brief is defined by the transformation of ends in purposes, from purposes to objectives, from objectives to criteria, criteria in more and more concrete technical specifications. Mental representation corresponds partially, as does the physical model.

By the definition of every model in a set of attributes, process P is then characterized by the succession of cycles: Brief1M1 (A11, A12, A1n), Brief2M2 (A21, A22… A2n): Brief NMN (An1, An2, Ann). Process develops a *system of*

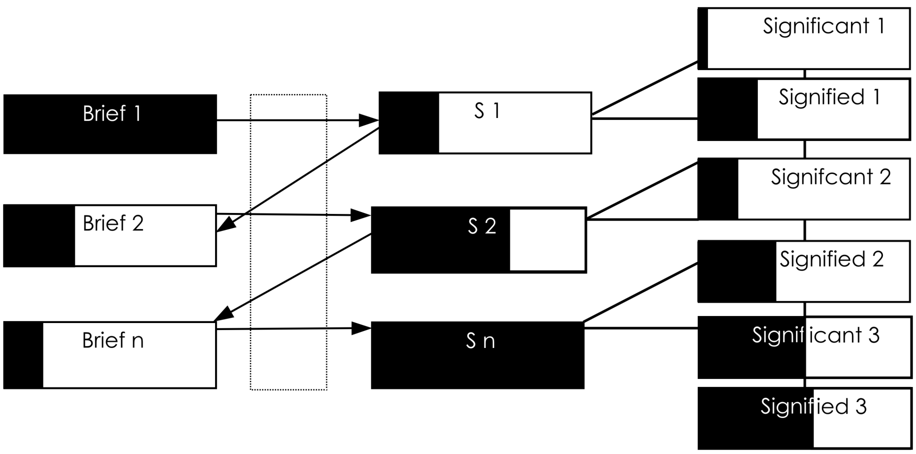

Figure 4 Design process considered as a sign sequence.

information (objectives) in a *signs system (solutions)*, of which recognition and evaluation allow the *production of new signs*. *Signs* emanate from the process of the mental composition of an *imaginary object* into an *object readily comprehensible* by anyone. The *design process* fits into the global plan of the process of conception presented above. The *solution space*, *in the context of design activity*, has, in particular the passage *of iconic signs in plastic signs*. The solution space is established by a *succession of modelled forms*.

The problem space (ends expressed) as well as the solution space (physical representations) are *punctually made explicit by the production of signs*, as verbal codes in the case of the brief, and Formal codes in the case of solutions. From a semiotic point of view, each Form M1, M2, is bound by a known referent, that is a particular and unnecessary real object member of a class which has its own appropriate physical characteristics, where the *significant* is linked to a *referent* by a relation of *transformation* (isomorphism, specific to the cultural character of the recognition codes).

According to these considerations, we modelized the process of car design according to the plan below:

4 Formalization of a global tool for the car manufacturer

According to us, the adequate strategy of the parts manufacturer can be based on an extension of the competence which requires three actions, namely (1) the introduction of new skills in accordance with demand like design integrating consumer's notion, (2) the introduction of new tools adapted to those used by the car builder and finally (3) a training and sensibilization of the current staff on design aspects. These actions can be supported by the introduction of two types of tools:

- system of information
- early model tools

4.1. Information system in car co-conception

Our model enabled the elaboration of a concrete tool, directed to the Project Management and assisted by the implementation of a co-conception-oriented information system favouring the permanent practice of Stylistic Awareness. Formal or informal information used in co-conception are essentially verbal and iconic codes, which are the object of formalizations (transcription, modelling,) and successive syntheses during the projects reviews. These various forms of information together constitute a common representation of the project that we call 'evolutionary model', structured around the functional brief of the system. Storage and recording of the model can be done in various ways, ultimately resulting in an evolutionary digital model. This one is intended to be communicated in the time and in the space, and possibly realized as physical and tangible information (printing), prototyping.

According to the model in Figure 5, one mainly finds tools connected (1) in the simultaneous or deferred formalization, (2) in the digital memorization, (3) in the communication and (4) in the realization. Realization tools primarily concern the prototyping technologies: CAD-CAM (computer assisted design and manufacture, stereolithography, . . .).

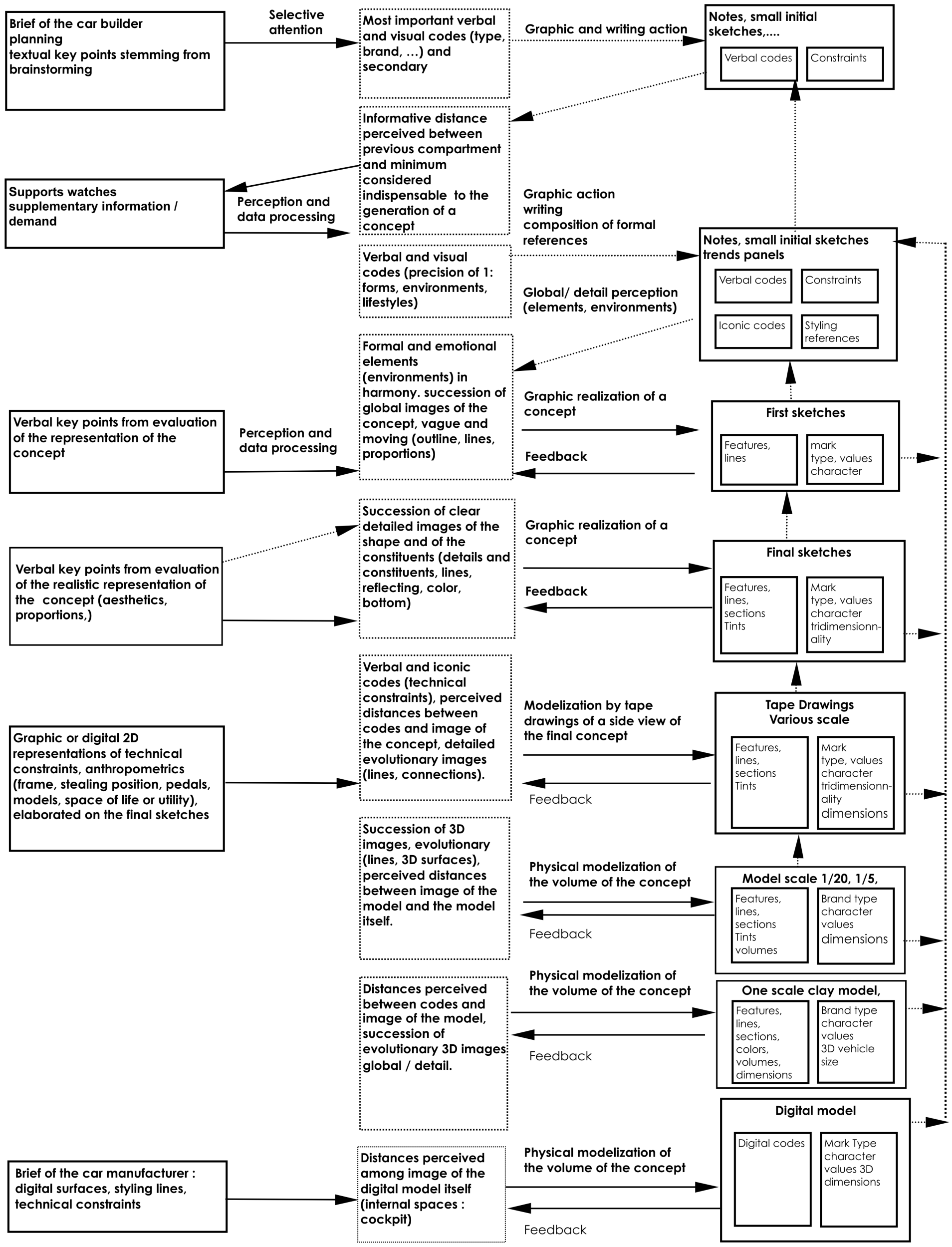

Figure 5 Modelling of the car design process [4].

4.2. Use and evolution of the digital modelling tools in the process of car design

Numeric tools for the generation of computerized images such as Alias or CDRS, are run from the passage of the information coming from the design departments to the engineering departments, to compare several variants with lower cost before

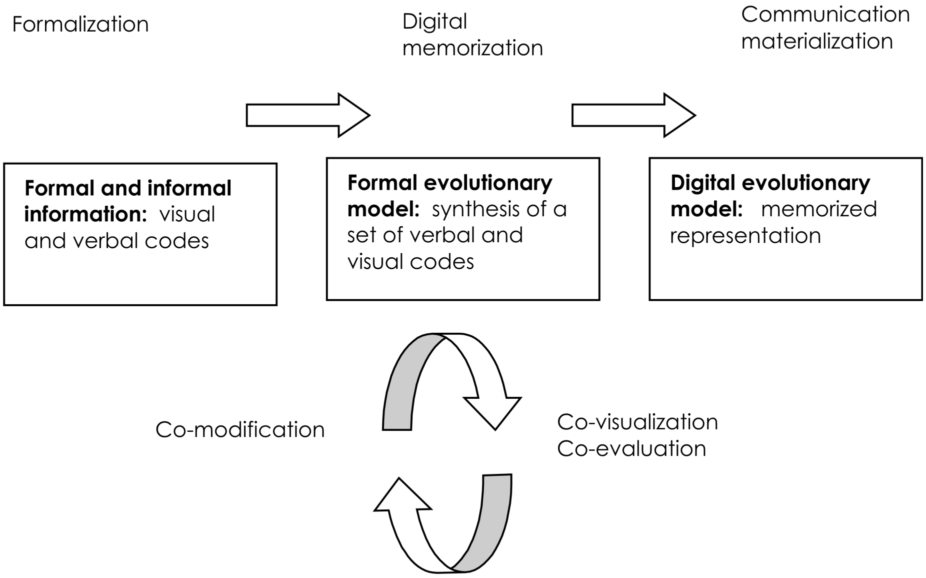

Figure 6 Informative model in co-conception [5].

making a selection. They produce a mathematical definition of the design which can be directly integrated into the supports of rapid prototyping. As indicated by Wardle [6], 'they eliminate the need for certain loops of model generation and consistently accelerate the activities of concurrent engineering to reduce development time'. They are particularly advantageous during a contribution from the car manufacturers to the design, where communication can then be done digitally. So the digital modelling tools tend to substitute themselves for traditional models with the development of New Computer Aided Styling software. This evolution an ever finer analysis of the activity carried out with conventional tools. In order to position themselves in a partnership logic with the builders, the car parts manufacturer will be confronted with the choice and the evaluation of digital 'Computer Aided Styling' tools.

In addition, co-conception occurs through the increasing use of co-software fitting into a new current method called computer aided collaborative work or computer supported collaborative work (CSCW), which concerns software packages evolving in shared environments. These tools keep a wide vision of the work [7] while optimizing the ratio of mutual prescription among designers [8]; in situations of conception characterized by a strong interdependence of the operators [7]. The co-conception software packages favour cooperation and coordination of convergent activities, through consideration and fast and efficient decision making.

4.2.1 Computer aided styling based on morphology, interpolation and geometric transformation (project supported by tatung company and the national science council in taiwan) [9]:

This software enables a lot of *generated mental ideas* to be expressed. They can be based on a *morphologic approach*: possibility to generate a large number of combinations with a systematic exploration, bearing in mind that the product

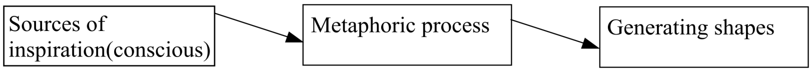

Figure 7 The generating styling stage.

consists of many basic elements with alternative combinations. After having first distinguished between the functions and the sub-functions, the designer combines the sub-functions into basic structures. This kind of approach is particularly interesting for exploring the modularity concept in car design, but the 'quantified structure approach is still extremely labour intensive'. Other methods are based on the *interpolation of shapes or morphing*, coming from mental images that represent a type of object. These systems can be applied in various areas of design to combine two different shapes at a certain level of combination. Approaches such as morphology, interpolation and geometric transformation have been used together in styling to take into account the syntactic and semantic dimensions. The process has been inspired by the following natural mental process:

The limits are the designers deductive part in conceptualization. This means: deciding upon the relationship between objects; how to select shapes and how to interpolate corresponding points.

4.2.2 Computer aided styling as fast shape design using a modeller based on sketch input with an object data structure (developed at the delft university of technology [10])

The Fast Shape Designer allows the designer to generate ideas while sketching at the same time. To start up with this software, the designer can either read in an old model, select curves in a library to create a new model, or sketch a new curve with the sketch Manipulator [9]. He must then reposition the curves in a 3-dimensional object space and identify the topology of the curve mesh by linking curves together. The final stage consists of filling in the holes in the curve mesh with smooth patches and changing the patches iteratively by sketching or repositioning curves. The system is completely interactive and does not require any precise value during sketching. It is closer to the architectural approach (2-dimensional->3-dimensional) than to the sculptural one, because it is based on curves sketched by hand in a freely positioned plane.

4.2.3 Computer aided styling based on sketches using a combination of extrusion and projection techniques (developed at coventry university – VIDE centre [11])

At Coventry University, a large research project in collaboration with car manufacturers (the Digital Mock up Program) 'concentrates on new modelling methods for the car industry, in order to support the design process from conception to manufacturing and, avoid the current practice of linking a variety of incomplete and expensive models of components and assemblies for design and evaluation purposes'. The initial stage is the integration of Computer Aided Styling into the process, to get early validation and manufacturing phases, through the use of a combination of enhanced sketching techniques, novel modelling approaches and rapid prototyping technologies. The new software enables the designer to 'produce

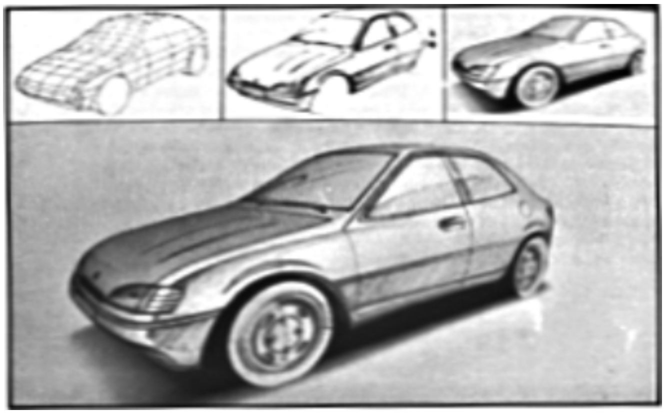

Figure 8 The genrating styling stage.

implied 3-dimensional computer models from 2-dimensional automotive concept sketches using a combination of extrusion and projection techniques'.

5 Conclusion

5.1 Influence of Digital Computer Aided Styling Tools on operator relations in the car design process

In the field of complex products such as cars, CAS software will have a big impact on relations between manufacturers and suppliers, with an earlier translation of data from the former to the latter ones. Currently, 'the full size model is used as the basis for all body surface information required by the engineering departments for structural design and analysis, and for tooling design and specification. It represents the main formal communication device between the stylists and the engineers' [11]. Suppliers may be able to transmit purposes earlier in the process, reducing the global time of conception.

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