

**NEW PRODUCT DEVELOPMENT IN A PLATFORM-DRIVEN ORGANIZATION : TOWARDS PLATFORM
LIFECYCLE MANAGEMENT.**

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ABSTRACT

Platform product development is now widely used to tackle the cost-variety dilemma. In this work, we questioned the planning hypothesis underlying most of the research on platform design. Using an inductive methodology, we analyzed the first phase of a product development belonging to the second generation of a product based on an existing platform. This led to three results. We pointed out the existence of platform design principles. We also brought up how a design based on an existing platform modifies the traditional V-model, which structures the design process organization. Eventually we outlined the question of the platform renewal and its impact on platform's architecture and flexibility.

Keywords:

Multi-project management, Platform Strategy, Design, New product development

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INTRODUCTION

Since the mid-eighties, companies face the double challenge of replacing products at an increasing rate along with satisfying more and more specific and diverse customers. These two requirements lead to the multiplication of new product development projects (Nonaka & Takeuchi, 1986; Wheelwright and Clark, 1992). Also, the cost of these developments must be controlled since price is as significant as the product itself for market competition. Furthermore, the project teams have to deal with the necessity to innovate, in order to put on the market attractive products while keeping under control the risks underlying this type of project. All these properties of the competitive context show the necessity for moving from a management of unique projects leading to “hits products” to the project management in a multi-project environment (Cusumano & Nobeoka 1998).

One of the responses that adopts a multi-product approach and has been deeply studied is the platform strategy (Meyer & Lehnerd, 1997). Works that analyzed this approach in comparison to the mono-project approach have demonstrated its superiority (Nobeoka & Cusumano 1997). Platform strategy corresponds to the process of identifying and exploiting commonalities among a firm’s offerings, its target markets and the processes for designing and producing their products. A platform is the common basis of the individual products of a product family which is the collection of products that share the same assets (Sawhey 1998, Robertson & Ulrich 1998).

There are many similarities between multi-project management and programme management. In a programme, projects form a coherent group that is managed in a coordinated way for added benefits (Murray-Webster & Thiry 2000) or share a common objective (Andersen & Jensen 2003). Following Maylor et al. (2006), the projects in a programme may be represented as a chain of projects, a portfolio of projects taking place at one point in time or as a network of interlinked projects. This representation is very close to the platform approach because on one considered platform we can have a succession of isolated projects, overlapping development projects or a succession of a group of projects corresponding to different generation of products. In this paper, we are interested in this last configuration. The platform strategy highlights some common issues with the programme management because as Turner (1999) pointed it, programme management includes the management of interfaces between projects. Furthermore a programme management involves the coordinated management of a series on inter-connected projects and other non-project work for the delivery of a specific package of benefits like the management of the technical basis of the platform which is not a project activity.

The concept of building product families based on platforms to create variety economically has been widely accepted in the literature. The question is not anymore about whether to invest in a platform or not but it is about the design of the platform (Cusumano & Nobeoka 1998). Works about platform design are generally based on the preliminary planning of the products which will be developed on this platform and on the capacity to anticipate the technical evolutions to which the platform should adapt as long as it is used (Robertson & Ulrich 1998). The design of a product planned on such a platform consists in reusing the platform components and developing only the parts specific to a new product. Thus, the advantage of platform strategy lies in the possibility to develop a large variety of products during the period

over which it is possible to anticipate the needs and the preferences of the customers as well as technological progress.

But this preliminary product planning is ineffective in dynamic competing environments where it is not always possible to plan the products. Hence, in some competitive environments and very dynamic industries, the period during which the product planning and technologies anticipation remain accurate becomes increasingly short and it is common to design products not planned when the platform was initially designed. How then to manage the design of such an unplanned product on a platform at the middle of its life cycle? The analysis of the impact of the platform's existence on these products developments is an important issue because these products are not exceptions and they question the relevance of platform strategy itself.

Therefore, in order to follow up the research on multi-project management in general and more specifically on platform design, we chose, in this research, to put the focus during the life cycle of a platform and not at its beginning like it is the case in the majority of the work on platforms. For that purpose, we carried out a field methodology research at a car manufacturer six years after the setting of the platform-based organization. We analyzed the first phase of a product development belonging to the second generation of products six years after the implementation of the platform organization. This analysis led us to three results.

We pointed out the existence of platform design principles, which influence the product development as well as market, economic or technical principles. We also brought up how a design based on an existing platform modifies the V-model, which structures the design process organization. We especially identified the consequences of this modification on the development organization and the coordination of the actors. Eventually, through our analysis of a product design during a platform life span, we outlined the essential question of the platform renewal and

the implementation of this decision. We addressed this question through the platform's architecture and its flexibility.

The paper is organized as follow. Section 1 reviews the existing literature on platform strategy and product design. In section 2, we present the research setting and our methodology. The case is presented in section 3. We then turn to the analysis and discussion (section 4) before concluding.

THEORETICAL BACKGROUND : THE PLATFORM STRATEGY

Product planning for platform design

In an intense and dynamic competitive environment, the reduction of the product life cycle and the increasing variety of customer demands lead firms to offer a big variety of products over time with an efficient use of resources. For that purpose, they leverage investments in design and manufacturing by implementing platform-based product development.

A platform is the common basis of the individual products of a product family which is the collection of products that share the same assets (Sawhey 1998, Robertson &Ulrich 1998). Platform strategy corresponds to the process of identifying and exploiting commonalities among a firm's offerings, its target markets and the processes for designing and producing their products (Meyer & Lehnerd, 1997). This strategy is an answer to the « fat design » phenomenon identified by Cusumano & Nobeoka (1998) as the down side of the heavy weight project management organization. They pointed out that it is useful for firms to overlap chronologically the projects sharing components : in that case the engineers can design components for more than one project. By coordinating chronologically overlapping projects a firm can transfer a design from a base project to a new one and facilitate task sharing among engineers as well as mutual

adjustments and communication between the interdependent projects. They show that merging concurrent multiple projects is beneficial for both the speed and the effectiveness of technology leveraging between projects.

Several research have showed that implementing the platform strategy increase the launch speed of a new product developed on the platform except in the case of the first product on the platform. In that case, the development requires more time and cost because it covers also the development of the platform (Halman et al. 2003). Except in this situation, the platform strategy leads to the reduction of the delay of the development, and of the resources necessary to the product development. It leads also to the increase of the quality of the product by using pretested components (Sanderson & Uzumeri 1995).

The concept of building product families based on platforms to create variety economically has been widely accepted in the literature. The question is not anymore about whether to invest in a platform or not but about the selection among platform alternatives.

The literature pointed out the importance of the strategic planning of the sequence of products that will be developed on the platform in order to design it. Cusumano & Nobeoka (1998) pointed the importance of this strategic planning to transfer component technologies : “it is more efficient for companies to make advance plans during the base project for future reuse of a platform”. Robertson & Ulrich (1998) propose a structured process for platform design based on three plans : the product plan in a first place, than the differentiation and the commonality plans. It is on the harmonization of these three plans that the success of the platform strategy depends.

What about this strategic planning when it comes to plan more than one generation of products on the platform ? Furthermore, this preliminary product planning is ineffective in

dynamic competing environments where it is not always possible to plan the products. Hence, in some competitive environments and very dynamic industries, the period during which the product planning and technologies anticipation remain accurate becomes increasingly short and it is common to design products not planned when the platform was initially designed. How then should be managed the design of such an unplanned product on a platform which is in the middle of its life cycle? Cusumano and Nobeoka (1998) pointed out that with an advanced plan, “*it is difficult for engineers in the base project to predict problems future projects may have in reusing the old platform design*” (p. 131). The analysis of the impact of the platform’s existence on these products developments is an important issue because these products are not exceptions and they question the relevance of platform strategy itself. We intend to focus on this open issue.

From the platform design to the platform renewal

The literature focused mostly on the underlying concepts and benefits of product family development. The seminal works on the platform strategies (Meyer & Lehnerd 1997, Cusumano & Nobeoka 1998, Robertson & Ulrich 1998) consider a product family starting with the initial development of a platform. But, as Halman et al. (2003) mention it, « this is not a one-time effort. New platform development must be pursued on a regular basis, embracing technological changes as they occur and making each new generation of a product family more exciting and value rich than its predecessors ».

Meyer & Lehnerd (1997) pointed out that long-term success and survival require continuing innovations and renewal. They analyzed the renewal of the platforms of HP in the printer business and proposed metrics to monitor the evolution of the platform (Meyer et al. 1997). New generation of products can either be based on an entirely new platform or a partial

renewal of the existent platform. For Halman et al. (2003), the partial renewal concerns one or more subsystems that undergo major changes in order to allow new features necessary for the second generation of products planned on the platform. A new platform is developed when the basic architecture changes are necessary. But the literature did not address specifically the question of the platform renewal. Several authors (Halman et al. 2003, Krishnan & Gupta, 2001, etc) pointed out the lack of indication in the literature on the moment when firms have to renew their platform.

The development of a succession of product generation on the same platform has not been addressed by the literature either. Literature has focused mainly on the initial platform development and on whether the right platform is chosen in order to develop enough follow-on products to gain back the investment and less on the implementation of a succession of product families on a platform. A clear gap in literature exists when it comes to implementing successive product families on platform and we intend to contribute to fill this gap.

Product Design in a Platform-driven Environment

The leading principle in the design of a product in a platform-driven environment is to decide which components of the product that be developed on the platform basis and which will be the differentiating elements that will be specifically designed for the product. This trade-off is strongly linked to the question of the product architecture. This question (i.e. the way in which the components are organized and interact) is one of the central preoccupations of the extensive literature on product design processes (Pahl & Beitz, 1996; Wheelwright & Clark, 1992; Ulrich & Eppinger, 2004), as it plays an essential role not only in the intrinsic performances of the product, but also in its evolution possibilities and in design process organization (Ulrich, 1995). Since the mid 1990s, studies of the interest and impact of modular structures have paid particular

attention to questions of architecture (Baldwin & Clark, 2000). Platform design has also been the subject of many publications aiming mainly to propose methods to manage the commonality / differentiation dilemma by taking account of technical, marketing/product and economic constraints (Ulrich & Eppinger 2004). However, these studies pay relatively little attention to the design process in a platform-driven environment which is perceived as not being fundamentally modified by the platform approach. This is probably consistent with the static nature of these studies looking into the question of the design of the first-generation platform, i.e. starting from scratch (or almost). However, when seen from a dynamic point of view, the question changes. As Fisher et al. (1999) mention it, *“in most industrial situations, there already exists a portfolio of products and the managerial problem is to decide which components to re-use, which components to replace, which to develop. This problem is complex and deserves further research attention”* (p. 313). We believe our work contributes to addressing this question of product development in a dynamic platform approach.

RESEARCH SETTING AND METHOD

In order to analyze the product development process in a driven platform environment, we conducted a longitudinal field-based study. Our research site was a leading European automotive manufacturer, Platcar (pseudonym), which adopted the platform strategy in 1998. The strategy was that at least two generations of vehicles would be developed on the platform which should therefore last about 10 years. We analyzed the first phase of a car development process belonging to the second generation of products, six years after the implementation of the platform organization. Below, we will present our research setting and the method employed for the data collection and analysis.

Research Setting

The automobile sector being one of fierce rivalry, the competitive advantage of OEM resides in their ability to control development and manufacturing costs, to meet a variety of customer needs as efficiently as possible and to reduce development delays in order to replace models frequently. The impact of the new product introduction rate on market performance may be particularly great in industries such as automobiles because technology is improving steadily in small increments and customer expectations are fragmented and change at a rapid pace. Therefore this sector is characterized by a common problem in many industries: the mass customization phenomenon. Fresh styling and model introduction in addition to functional performances have a significant influence on sales (Clark & Fujimoto 1991, Nobeoka & Cusumano 1997). Furthermore, the automotive industry has been studied by seminal works on platform strategy such as Cusumano & Nobeoka (1998) and Robertson & Ulrich (1998).

Platcar is a medium-sized generalist OEM (200,000 staff and 3.5 million vehicles sold around the world in 2005). It is among the top three in Europe (14.5% market share) and the 7 biggest in the world (5.5% market share). Towards the end of the 1990s, the automotive sector in Europe was marked by an increasingly intense and widespread price war, leading to severe pressure on OEM margins. The company's new management at that time set the target of "*restoring innovation, growth and profit*". To achieve this, Platcar set up in 1998 a new organization structured around three key points: adoption of systems engineering, simultaneous product process design and the structuring of products around three platforms of different vehicle sizes. This organisation also has industrial incidences : the platform is not just a technical object combining common components to several vehicles, but corresponds also to an industrial organisation as these vehicles are manufactured in the same factories organized around these

common components. The platform comprises the chassis, power train, gearbox, steering column, fuel tank and exhaust, (front and rear) running gear and seat frames. It also includes the electrical and electronic architecture and the air conditioning circuit. This represents 60% of the value of the vehicle but is invisible to the customer and does not have a great influence on the silhouette and style of the vehicle.

We focused in this study on the smallest platform (referred to hereafter as PF) representing 34% of Platcar sales in 2005. Competition is particularly fierce in this market segment occupied by the main European generalist OEMs. Finally, in this company, this segment has always served as a pilot unit for implementing organizational innovations. For example, it was on this platform that a project management office was first set up. Our choice of the PF platform is therefore justified by the competitive industrial background in general and the specific context of PF in Platcar, as it can be considered as being ahead of the rest of the firm.

From 1998, date of the implementation of the platform organization, to 2001, 5 cars were developed on the basis of PF. In 2002, the question of the development of the second generation of vehicles on PF was raised. The strategy adopted by the company was to re-use PF and develop these new vehicles on it. The first tensions emerged at this point. Four years had passed since the design of PF, and new requirements in terms of regulations and consumer expectations had emerged. With the second-generation projects, PF had to be modified to comply with these new regulations and new customer tastes. This obligation was noted by the team in charge of PF in its analysis of the three new second-generation vehicles provided by the product plan . This team was responsible for managing the re-use of the platform components and taking account of any demands likely to make it change. In this respect, the second-generation vehicles could be a

source of improvements of PF¹. The PF team identified the different technical enhancements required by the most innovative versions of the second-generation projects.

We analysed the development of a new vehicle on PF at this time. This case was particularly relevant to the research question we had identified, which is the impact of the platform-driven environment on the product development process during the life cycle of the platform.

Method: data collection and analysis

To be able to describe the design process empirically, we used a field based methodology (Glaser & Strauss, 1967; Yin, 2003). Our research was grounded in a case study of a car development project. Most research into platform strategy proceeds on a quantitative basis focusing on the performances of this strategy (Cusumano & Nobeoka, 1998; Krishnan & Gupta, 2001; Fisher & al. 1999). Our aim here is different and requires in-depth analysis of the designers' practices in a platform environment. The product development case was selected by theoretical sampling (Eisenhardt 1989), meaning that it was not chosen for statistical reasons but because it was particularly relevant to the question of the product design on an existing platform. As we showed in the research setting, Platcar had chosen to maintain the platform for several vehicle generations. We focused on the first phase of the development process because it is from this very early stage that the product designers have to consider the integration of the product onto the platform. This phase lasted one year (2004). The data was collected over a period of 15 months (April 2004 to June 2005).

¹ In return, the modifications to PF may also be of benefit to the first-generation vehicles by retrofitting new updated PF components on the vehicles designed on the basis of the initial PF in order to maintain the level of common components, improve performance and reduce costs.

One of the authors is an insider, being an engineer in the team in charge of PF. The two other authors are outside researchers independent of the relevant organizational settings. They are academics who provided preliminary research questions about the challenges of design in a platform context. The research is also the result of long-term collaboration with Platcar : beside the insider author, one of the academic authors has previously conducted longitudinal research on the design processes in this firm over a period of three years. This provided stable relationships and historical understanding of current management problems and strategies. The trigger for the research project was rooted in the joint interest of the firm and the authors in learning more about the design challenges in platform-driven environment.

Data was mainly composed of two types : the minutes of the regular platform meetings and the documents presented during these meetings covering 5 years from the launch of the platform organization and interviews with key members of the product development team. As mentioned above, one of the authors was an engineer within the team in charge of the technical base and as such she had participated in the first phase of the product development. Beside the traditional individual analysis of the data by the authors, they shared their analysis during research meetings that were held on a monthly basis. The authors worked together on a regular basis (a 4-hour meeting once a month) during the 15 months that the research lasted. During this period, the authors also had regular meetings with the platform and technical base management. These meetings lasted 2 to 3 hours and were held quarterly. The global result was a description of the design process that was also presented to the product development members for validation.

Following Krishnan & Ulrich (2001), we adopted a decision perspective that “helps us get a glimpse inside the black box of product development”. We focused on decisions taken during the first phase of product development because at this stage decisions concerned mainly

the product concept and architecture, and in particular whether the product would be developed on an existing platform or not. We focused particularly on the knowledge mobilized to take these decisions. Following an iterative study, the authors examined their data repeatedly and clustered the knowledge into four categories. The impact of each category on the design process was discussed.

Two specific features of the research approach should be emphasized. The fact that one of the authors was an insider gave us unique access to data and deep insight into the course of events since she had really been there. The risks of ex post rationalizations due to personal interests in the case studied that could be associated to such closeness were deliberately addressed by the insider/outsider relationship between the authors.. We also tried to get different perspectives of the subject under study by validating the process with other people who had been involved. The second point is that we have a single case study. This is not a problem since our aim is to provide new insight rather than to verify established theories (Eisenhardt, 1989). The product development process in an existing platform has never been studied from a qualitative, empirical point of view. We are not claiming that our findings are universal or that they reveal any statistically significant phenomena. They do throw light on the design process in this environment.

CASE STUDY

Development Process : main phases and players

As mentioned above, to analyse the impact of re-using a platform from one generation of vehicles to another on the process of designing a new vehicle on the platform, we will focus on a vehicle project scheduled on this platform and belonging to the second generation. We will focus

more particularly on the beginning of the design process: the pre-project phase prior to the official project launch. The overall Platcar product development process comprises 4 phases : the pre-project phase ends once the product has been positioned on its market and the main characteristics of the product defined. At this point, the project director and core team are appointed: this is the project launch. During phase 2 that follows, this small team chooses a concept and an architecture, style guidelines and initial product specifications. This is followed by phase 3 ending with the choice of style and suppliers. Finally, development phase 4 (the longest) brings the product design process to a close.

Three departments play a role in the project : the department in charge of strategy and products, which establishes the product plan, the department in charge of innovation and, lastly, the technical department in charge of development and industrial transfer of vehicle projects, including their commercial life. This department designs the product and industrial process at the same time, and assists the group plants. It covers the platforms, the technical and support functions and the purchasing. The mission of the platforms teams is to reconcile the specific objectives of the projects and the common objectives, as well as the continuity of the technical base corresponding to each platform. They handle adapting the vehicle to the platform, integrating innovations and steering all the activities of production and normal life. The technical and purchasing functions provide the projects with the skills, services and technical expertise required to achieve their objectives. They guarantee the competitiveness, quality and security of supply of the products purchased, developing and implementing all the industrial facilities. Lastly they provide technical support to the plants. The support departments (costing, quality audit, prototypes, homologations, nomenclatures) contribute to the action of the projects and

handle the general activities such as the personnel, technical secretariat, management, quality, budgets, IT and communication.

We focus here on the pre-project or first phase in the design process starting in 2004. Although the product architecture will be chosen in the course of the following phase, the fact that the vehicle is being developed on the platform means that even at this very early stage, some of the available technical solutions for the future vehicle must be studied and the initial outline of the architecture for the vehicle must be drawn. A small PF team belonging to the technical department was therefore appointed to conduct these studies, using data from the product department. It should be noted that the project team has not yet been appointed at this stage.

Data presentation

As we mentioned above, we will focus on design decisions. To represent the design progression, we use a design for creative thinking and innovation model called CK proposed by Hatchuel & Weil (2003). They emphasize on the distinction between concepts (C) and the knowledge (K). A concept is a proposition that has no logical status in the knowledge space K: it is neither true nor false. The exploration of a concept is the creation of new concepts from the initial one by adding or subtracting new properties: this is the partitioning of the concept. The design results from the expanding partition of concepts. In order to achieve this expansion, the designers need some knowledge. They held that when this knowledge does not exist in the firm (in the functional department of the firms) the designers develop it (“knowledge expansion”). The designers “move down” the design tree structure partitioning concepts. The C-K model represents the exploration of design possibilities, the mobilisation of knowledge and the

successive movements back and forth between the concept space and the knowledge space that guide this exploration (Figure N°1).

Insert Figure 1 about here

Throughout the analysis, we will attempt to distinguish between the types of knowledge mobilized or created during the design process. We have identified four types. Three of them are relatively traditional: technical knowledge (product and process engineering), product knowledge (meaning everything perceived by the customer as being style and performance, for example) and economic knowledge (aiming to maintain project profitability). A fourth type of knowledge emerged from our analysis: this relates to the platform. This fourth type of knowledge will be analysed later in the discussion. We will use the symbols below to represent these types in the figures retracing the design process (cf Figure N°2).

Insert Figure 2 about here

In 2003, the common base for several vehicles is a set of modules (three driver environments, three rear units...) combined around a common core (the floor pan and engine compartment) (Figure N°3). Unlike modular architectures (Baldwin & Clark, 2000) these are not totally interchangeable.

Insert Figure 3 about here

For reasons of confidentiality and simplicity, we will represent the base by the assembly of four modules, A, B, C and D, represented by different geometric shapes. Certain modules exist in different versions corresponding to different performances in terms of cost and functions. These modules are connected by interfaces, which we represent in the form of notches of varied geometric shapes (figure N°4).

Insert Figure 4 about here

Module A is common to all the vehicles. At the beginning of the project studied, there were two types of B modules (B1 and B2) connected to module A via the same interface (represented by a triangular connector). These two B modules are therefore interchangeable. There are also two C modules (C1 and C2), connected to module A via the same interface (semicircular connector). These two C modules are also interchangeable. Lastly, there were two D modules (D1 and D2), connected to the B and C modules via specific interfaces. Module D1 goes with modules C1 and B1 while module D2 goes with modules C2 and B2. The two D modules are therefore not interchangeable.

The Pre-Project Phase Design Process

First Stage (Figure N°5)

The decision to build the new vehicle on the platform supposes that it is constructed around the A module that is common to all the vehicles on this platform (arrow1 a1). Since the aim is to keep as much as possible in common between the vehicles, the second design decision concerns the B module which exists in 2 versions (B1 and B2). The initial concept of “build the

new vehicle on PF1” is therefore partitioned into two (a2). On a given function, the performance of concept AB2 is excessive in relation to the product plan (a3). The possibility of a new, lower-performance, cheaper B3 module is therefore envisaged (a4) but soon abandoned in the name of maximum commonality (a5). This A+B3 solution also poses problems of industrial feasibility (a6).

Insert Figure 5 about here

Second Stage (Figure N°6)

The exploration starts again from option A+B1 and now turns to the C module that also exists in two versions (C1 and C2; a1). These two modules have different characteristics resulting in different performances for customers. Negotiations are therefore started with the Product Department regarding these performances. There are also new technical issues that make the use of C1 uncertain. Other negotiations are therefore conducted in parallel with the technical departments regarding the acceptability of C1 (a2). Lastly, there is also the question of compatibility with the D2 module that necessarily goes with the C2 module (a3) but would appear, at first sight, not to be compatible with the B1 module. Studies are therefore launched to study the possibility of combining them (a4 & a5). Two designs that are compatible with Product Department requirements are therefore proposed by the team: A+B1 and A+B2. The team proposes to study them in more detail. The questions remaining open concern technical points (acceptability of module C1, compatibility of B1 and D2 modules) and the product/style (choice of module C).

Insert Figure 6 about here

Third Stage (Figure N°7)

The exploration continues. Module C1 does not comply with a technical policy. It is therefore ruled out. As a result, the two designs being studied now both use module C2 (a1). As well as this, a first study shows that module D2 is not technically compatible with B1. This design is therefore ruled out and the design of a new module D2* that is compatible with both modules B1 and C2 is envisaged (a2). The second design originates from the A+B2 combination (following the tree structure). It restores module D2 as being compatible with modules B2 and C2

Insert Figure 7 about here

Fourth Stage (Figure N°8)

The Product Department now judges that the production cost of the designs being studied is high. Although the assessment can only be relative at this stage, module C1 seems much less expensive than module C2. The Platform Department is also in favour of C1 for reasons of commonality between the future vehicles in the range. As a result, the design including module C1 is again envisaged for economic reasons, despite the fact that it had initially been ruled out for questions of technical policy. This C1 module is associated with module D1 that has an excessively high production price because it uses older technology than the D2 module (a2). The

possibility of designing a new module D1* with the same interfaces as the D1 module but a lower manufacturing price is therefore considered (a3).

Insert Figure 8 about here

Shortly before the official project launch, there are therefore three vehicle design hypotheses in competition: H1, H2 and H3. No single concept is completely satisfactory. Table 1 summarizes the advantages and drawbacks of each design in relation to the main criteria of the product (style, performances, product characteristics) and platform (technical impact on the base, industrial factors, production cost). For each criterion, there are three levels: favourable (++), moderate (+) and unfavourable (-).

Insert Table 1 about here

Given the available resources and the company's determination to limit the number of designs studied in order to reduce design delays, one of the hypotheses must be ruled out at the time of the project launch. The final choice of architecture will be made one year later at the end of phase 2, once the project team has been appointed. At the time of the project launch, the debate is therefore open, with each stakeholder defending the hypothesis that favours his own key criteria. The newly-appointed project team takes part in this debate after familiarising itself quickly with the various hypotheses.

- The project team members who have arrived a few weeks before the project launch to facilitate knowledge transfer, prefer H3. It seems to them the most positive in terms of

customer performance and style, as well as technically in that it is based on existing modules, thereby limiting the risks of the project drifting off course. It seems to guarantee the best project profitability.

- The Product Department, meanwhile, wants to drop hypothesis H3 for reasons of product market positioning. It is very much against this hypothesis as it poses problems of coherence with the rest of the range.
- Lastly, the PF team is defending H1 that corresponds to the lowest-cost design, allowing better profitability of the project while guaranteeing the greatest possible commonality with the other vehicles, even if it does generate more technical modifications of the base.

Fifth Stage: Project Launch (Figure N°9)

Finally, on the project launch, the General Management chooses H1 (A+B1+C1+D1*) and H2 (A+B1+C2+D2*) but asks the project team to look for alternatives to designing a new D module in order to ensure the project remains profitable and reduce variety within the platform. The team therefore envisages modifying B1 to make it compatible with D2 and/or coming back to the AB1C1D1 solution on the grounds that it requires very little investment despite a high manufacturing price (a2). Starting out from two hypotheses at the start of the project, the project team must explore four designs to finalize the product and its architecture.

Insert Figure 9 about here

DISCUSSION

The Design Principles in a Platform-Driven Environment

In order to analyse the first phase of the product design process on an existing platform, we adopted a model highlighting the knowledge mobilized to enlighten the decisions made during the design process. Four categories of knowledge emerged from the analysis: product knowledge, economic knowledge, technical knowledge and platform-related knowledge. The mobilisation of these categories was identified at each stage in the design process (Fig N° 5, 6, 8 and 9). Below, we discuss the 4th category of knowledge that we call “the design rules”. We have seen that the design rules were mobilized right from the beginning of the exploration, along with product knowledge and before technical and economic knowledge (Fig N°5).. Detailed analysis allows us to distinguish three rules which we will illustrate below.

R1: Carry-over and limited variety

R2: Lean design

R3: Enlightened carry-over.

R1 and R2 represent the very definition of platform strategy as presented in the literature. R1 corresponds to the re-use of as many elements as possible of the platform on the developed products to limit variety. R2, or lean design, means that the design process is conducted using undersized elements and scaling them upwards, rather than oversized items that increase performance and costs needlessly. The players talk of “bottom-up design”. This rule avoids the problem of overdesign (Krishnan & Gupta, 2001) that is one of the risks of platform strategy. These rules have a major impact on the design process. The initial concept² “build the future vehicle on the platform” therefore originates from the *design rules*, since there is a highly

² As used by Hatchuel & Weil (2003) in their design theory, and not in the sense of vehicle concept

restrictive partition of the concepts space product. Only concepts retaining module A and existing modules B, C and D will be studied, thereby automatically excluding solutions that are more specifically adapted to this vehicle. Likewise, R1 & R2 are found at the different stages in the design process (Figures 5, 6 & 8). The players continue to strive to re-use existing elements, to keep as much elements in common and limit variety.

Our data also highlights a third rule that we did not find in the literature that treats mainly of the design of products on a new platform, but rarely the re-use of an existing platform for several products over a long period of time (more than 6 years in the present case). Analysis of the design process shows that the first two rules suffer many exceptions. R1 & R2 can be brought into question by other knowledge and the examples studied below illustrate these situations. Taking the example of the 4th stage, after opting for module B1 and C1 (by applying the R1 and R2 rules), it is therefore module D1 that should be chosen. But as the existing module D1 has an excessively high production price, the design of a new module D1* is considered, thereby violating rule R1. Application of this rule is therefore brought into question by an economic criterion (figure 10, left hand side). We can easily imagine other considerations that could result in the application of these rules being brought into question, such as compliance with standards, for example.

Insert Figure 10 about here

We take the example of the 3rd stage. After opting for module B1 and C2 (by applying the R1 and R2 rule) it is therefore module D2 that should be chosen. But the existing D2 module is not compatible with B1 (because the platform is not modular and certain modules are not

interchangeable), so the design of a new module D2* is considered, thereby violating rule R1 (figure 10, right hand side).

The same goes for the 5th stage at the end of the design process when the design of a new interface for the B1 (B1*) module to make it compatible with module D2 is considered, thereby challenging the rules of re-use, reducing variety and controlling development costs and time (fig N°11). In the latter example, the design rule banning the creation of additional variety and favouring the carry-over of existing elements is overturned by the management in the choice of designs at the product launch. This challenging to the rules does not correspond to criteria such as the economic or standards. They result directly from the non-modular nature of the platform, highlighting the limits of re-use of the components of a non-modular platform for several products over a period of time.

Insert Figure 11 about here

We have designated these challenging the rules R1 and R2 by **R3 the “enlightened carry over”** as it consists in enlightening re-use decisions. This must not be done at the expense of economic, regulatory or technical compatibility considerations.

We draw three conclusions from these rules. First of all, they show that these rules are a vector of integration of the platform approach into the design of a single product on this platform. Since 1998, development projects have been the basic entity in designing new vehicles at Platcar. In this context, these *design rules* make it possible to integrate the platform approach that is by essence a multi-product one into the single-product design process. This category of knowledge, revealed by the C-K model, therefore distinguishes itself fundamentally from the knowledge traditionally mobilized in new product design (product, technical and economic).

Secondly, analysis of this case shows that platform design cannot simply be limited to the question of re-use of existing elements to design a new vehicle. As soon as we begin to analyse the pertinence of re-use, a new design process begins with the associated features such as the uncertainties, the iterations, the discussion and back and forth movements, etc ... We highlight that what is relatively new in the mobilisation of rules favouring re-use in product design is the stage at which this re-use is examined. In fact, the platform-related rules are brought into play at the same time as product knowledge, and before the project team is appointed. These explorations are conducted by the team in charge of the platform in interaction with the Product Department. This examination of re-use so early on in the project is remarkable in a company, like many others, in which the product is legitimized first by the Product Department for which the team is developing the product. By this, platform considerations take on the same importance as product ones.

Finally, we have observed that the degree to which the principles are challenged varies depending on the situations and modules. In the case of the first example (Figure 10) the decision was made very early on to design a brand new module D, for technical and economic reasons, whereas in the second example (Figure 11) it was only late on that authorisation was given to re-design just a part of module B1, in this case its interface with module C. More generally, we have noted that this bringing into question of platform design rules was backed by very high-placed people in the hierarchy. A certain level of legitimacy is therefore required to justify giving up these rules.

Modifying the V Model and its consequences

The points above show that design on an existing platform represents a break away from the habitual design process. In the case of design without any carry over, corresponding to traditional design projects, it follows the pattern of the V model (Figure 12 left hand side). This method originating from the theory of Systematic Design (Pahl & Beitz, 1996) divides the design process into two broad stages: a specification stage (the left-hand side of the V) and then a validation and synthesis stage (the right-hand side of the V). In this vision of things, the design process begins by an analysis of needs followed by the search for a concept and then a feasibility study resulting in specifications (the functional terms of reference). On this basis, architectural design and detailed design can then begin. It is therefore *what we want and what we can do* that serves as the sole entry point of the design process. The issue consists in finding the best response to the specific question asked at the beginning of the process. In the typology of Cusumano & Nobeoka (1998) this applies to traditional projects (type 1: new design), and also to designing the first-generation platform in a strategy of *concurrent technology transfer* (type 2) where the team can think through the commonality between the two projects. In this last case, the content of the design work is therefore modified, but the process itself is not.

In the case we are studying here, the common elements are imposed to the team in that it must deal with existing elements that have not even been designed originally for the product it is in charge of. The V model is thus modified fundamentally. Now, *what we want and what we can do* is no longer the sole starting point. There is a second entry point: *what we have and what we re-use*. The design process for the part of the product corresponding to the platform (the vehicle base, in our case) must now take account of elements that already exist, meaning elements of

which the design is already at a very advanced stage in the V model (at the detailed design level, Figure 12 right hand side)

Insert Figure 12 about here

Design of a product on an existent platform is therefore a real revolution compared with traditional development, because the designers start out with two inputs rather than just one. One of the major issues is therefore to bring about a convergence between these two points. Our research shows, in other terms, that the V model shifts towards a W model: after an initial exploration of the possibilities for convergence between the specifications of the new vehicle and the existing elements of the platform, a new cycle starts to get these two worlds to converge. This type of shift is visible in our case when, for example in stage 3, the team decides to start again from the A + B2 solution to explore new possibilities. The difficulty then lies in keeping control of the process. As is sometimes observed in the software field (Cusumano, 2004), the risk is one of losing control of the design process: faced with unsuitable existing modules, some of them are redesigned, thereby causing others to be modified and so on. There is then the risk of entering into a never-ending cycle and losing the initial savings brought about by platform design.

The shift to the W model raises several questions. The first is cognitive in nature. Platform design upturns the design practice and view of engineers (Bucciarelli, 1988). In the course of our study³, we had the opportunity to note that this specificity of platform design posed difficulties to the professions in charge of detailed design and implementation (the tip of the V).

³ This data is not from the design process phase presented above, but we remind readers that our study lasted almost two years and that we had the opportunity to continue our analysis of the design process.

These professions are used to working in the V design model, which is to say designing parts on the basis of precise specifications drawn up by the functional stakeholders (in charge of the top of the V). They are reluctant at the idea of designing on the basis of specifications and existing physical elements which, as far as they are concerned, are not the same thing (the specifications do not necessarily correspond to the existing elements). On top of this, they do not yet have the tools they need to make decisions on the re-use or replacement of a component (Fisher & al., 1999). This probably represents an important subject for future research.

The second question raised by the shift from the V to the W model is that we are faced with a modification of the prescription relationships established between the design players. Hatchuel (1994) showed the importance in design activities of the organisation of prescription relationships between the protagonists. Briefly, the participants at the “top” of the V (in our case architecture and functional specifications) are in the role of the prescriber, while those at the “bottom” of the V (in this case the technical professions) do their design work in line with the instructions given. The approach here is very different, however, since the specification work is not conducted prior to the design work. The “top” and “bottom” of the V must therefore work together. The question of organizing this cooperation remains open. It constitutes an upheaval in the traditional prescription relationships between the functional and technical. The consequences and terms on which a reciprocal prescription relationship is established between these two worlds opens up a wide field for research. In particular, the question is raised of the modification of the planning method produced to integrate the constraints imposed by the existing platform architectures well upstream. One possibility could be to group these professions together in sub-groups of the platform or by functions.

Lastly, the third question refers to the progress of the design process itself. The strength of the project teams resides in their ability to focus energies around a shared target and implement solutions that are precisely tailored to this objective. This represents their freedom and their strength. Platform design reduces their capacity for action considerably however. It introduces into the process elements that already exist and cannot be modified easily since they correspond to strategic choices of the firm. Challenging platform design rules therefore logically supposes the intervention of highly-placed people in the firm hierarchy as it is a strategic decision (technically, industrially and economically). In this way, the design process is greatly modified and project autonomy reduced. The project team can no longer decide alone, and while this may combat the risks of project excesses (notably the *fat design* highlighted by (Cusumano & Nobeoka 1998) we can wonder as to the long-term efficiency of this logic of re-using existing elements. The need to go high up the hierarchy to settle issues is likely to prolong the design process. Although our data does not allow a comparison between the performances of the two approaches, there is no doubt that this is an important question for future research. This raises the issue of the sustainability of a platform re-use strategy over time.

Towards Platform Lifecycle Management

The literature dealing with platform design highlights the importance of prior planning of the products to be developed on the platform and sharing common parts. The issue is to determine what will be common to the different products and what will be different. Ulrich & Robertson (1998) thus stress the need to ensure iterative consistency between three plans: product, differentiation and commonality. It is on the harmonisation of these three plans that success of the platform strategy depends. In this way, the lifespan of a platform or the timescale within which it must be designed need to be consistent with the period of time covered by the product

plan. Indeed, design of the platform supposes choices of technology that will then be frozen throughout the period of use of the platform. Beyond this, it is therefore not possible to forecast products accurately or to anticipate evolutions in the platform. In the light of this, the question is raised of platform strategy performance in sectors in which technologies evolve rapidly, on the one hand, and in which product plans also evolve quickly to respond to changes in client preferences, for example. Other researchers have already identified the limits of product planning. It is on the harmonisation of these three principles that success of the platform strategy depends. For example, Cusumano and Nobeoka (1998) show (p. 131) that with an advanced plan, *“it is difficult for engineers in the base project to predict problems future projects may have in reusing the old platform design”*. They thus show that *“some engineers commented that design requirements often change after they complete the original design for non technical reasons. These reasons include changes in perceived customer needs, market competition or governmental regulations, especially when the time lag between the completion of the base design and the transfer to a new project is long”* (p. 133). This obliges the engineers on the second project to develop new components, thereby extending design times.

We are touching here on one of the current limits of research into platforms that has so far adopted a static approach of evaluating platform strategy against the former single-project strategy. Our study of a platform re-use strategy over several product generations shows the relevance of the platform strategy in a new light.

The first question raised is that of the lifespan of the platform. Our research shows how difficult it is to re-use a platform over time. This point has been the subject of little attention in the literature. Cusumano & Nobeoka concentrate on the strategy of *concurrent technology transfer* while Meyer & Lehnerd give examples of platform renewals at HP, for example,

without stating when or why the switch-over was made from one platform to another. We can therefore wonder what the scope of relevance of a platform strategy can be:

- Is it, as is often stated in the literature, a factor of flexibility and responsiveness against a background of fierce competition in which it becomes necessary to satisfy ever-more fragmented, changing customer expectations? Our research highlights a contradiction in this respect, in that it is necessary to plan the products and anticipate technological advances to design an effective platform...but this planning is awkward to achieve.
- Or does the advantage of platform strategy reside only in the fact that it makes it possible to design, more quickly and at lower cost, a wide variety of products *for a relatively short period of time* over which it is possible to foresee needs and trends among customers on the one hand, and technological progress on the other?

We can identify two approaches to these issues. The first, following on from the work of Krishnan & Gupta (2001), could consist in trying to estimate the optimal lifespan of a platform by comparing empirical data and theoretical models. In such an approach, platform strategy would only be effective if the platforms were renewed regularly. The problem of platform renewal would then be posed in the same way as product renewal, but on a different timescale. The second approach, taking account of the contribution of our discussion on reciprocal prescription (cf. previous section), would pose the question of the organization of the process of designing the platform described notably by Ulrich & Robertson. The difficulty here is to organize the interaction between the strategists on the one hand and the technical professions on the other. The objective would be to move from a principle of strategy prescribing to the

technical side to a form of interactive planning (Ponssard & Tanguy, 1993) in which each plan (product / differentiation / commonality) integrates the requirements of the others.

One last question brings us back to current research into the architecture of the products and their impact on design processes (Baldwin & Clark, 2000; Sosa & al. 2004; Mc Cormack & al. 2006). We have shown that the design of a second generation of vehicles (the first having led to the development of 5 products over 5 years) on the platform required the latter to be modified. But what is remarkable is that only certain parts of the platform had to be modified to receive the new products that were planned. What this case shows is that renewal by parts is sometimes hindered by the non-modular architecture of the platform. This shows the interest of modular architectures in highly dynamic environments in terms of techniques and the market (changes in customer needs and legal requirements). Yet while literature on product modularity is plentiful, that on platform modularity is less so. The question is therefore to determine the extent to which it is possible to design a modular platform in the automotive sector that is often presented as the archetype of integral architectures.

CONCLUSION

Analysing the design process of a product on an existing platform at the middle of its life cycle enabled us initially to formalize three platform design principles or design rules. The first two rules emphasize on the reuse of the platform components for the product design planned on this platform and on the struggle against the overdesign that must remain a constant concern for the people involved in order to the platform strategy gives all its beneficial effects. We proposed a third rule particularly pertinent in the case of the reuse of the platform components on a product in the middle of the platform's life span. This third rule enlightens the reuse and carry

over principles in the specific case of new generation products planned on the existent platform. This enlightened reuse takes into account economic, technical and strategic issues likely to complexify the course of the design process. These rules are a vector of integration of the platform approach into the design of a single product on this platform. They are brought into play at the same time as product knowledge at the beginning of the product development highlighting that platform considerations take on the same importance as product ones. These rules are backed by very high-placed people in the hierarchy. The design of a product in an existent platform is therefore a real revolution compared with traditional development, because the designers start out with two inputs rather than just one. The traditional V model shifts towards a W model: after an initial exploration of the possibilities for convergence between the specifications of the new vehicle and the existing elements of the platform, a new cycle starts to get these two worlds to converge. This shift has cognitive and organizational consequences on the product development.

Beyond these principles, our work questions the sustainability along time of a platform-based design strategy. Indeed, whereas this approach appears in the literature as a favoured mean to manage the cost/diversity dilemma, our research invites to moderate this assertion when it comes to consider the life cycle of the platform. Unquestionably platform design makes it possible to control development cost and delivery for the first generation of products. But the conclusion is not as clear as we consider products to be designed later. Indeed, it is not possible any more to plan formerly the various products that will be designed on this basis. Managing the merging of the existing components and the new product's demands outlines, as we have shown, several questions. The central issue, which we pointed out here, is the issue of the platform renewal and the implementation of this decision. Ongoing research is necessary to create

management tools integrating the specificity of the platform design (notably the modification of the design process) and making it possible to evaluate the “optimal” life span of a platform. Two ways of research can be outlined. The first would study, as Robertson & Ulrich (1998), the organization of the necessary planning process in order to reconcile platform design and rapid, and sometimes unpredictable, evolution of the competitive environment. The second would concentrate on the architecture of the platform to make it flexible. Works on the modularity of the products would constitute an extensive reference frame.

The answer to these questions will need a close cooperation between researchers and insiders to combine theoretical rigour and empirical data. Our work, which is limited to one case in the specific context of the automotive industry, is one first contribution. Other studies, in different environments, may answer these essential questions, taking into account the evolution of the international competition and the constraining necessity for the firms to manage, in constantly renewed ways, the cost/diversity dilemma.

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FIGURES AND TABLES

Figure 1 Representation of the design thinking based on the CK model. Hatchuel&Weil 2003

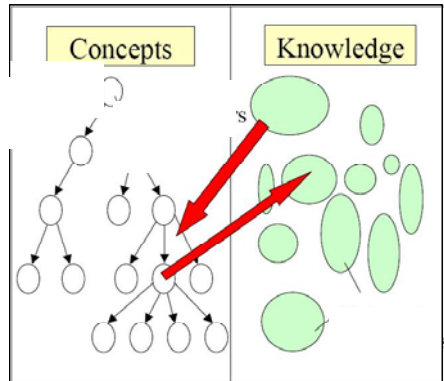


Figure 2. Types of knowledge mobilized in the design process



Figure 3. Representation of the existing platform elements in 2003

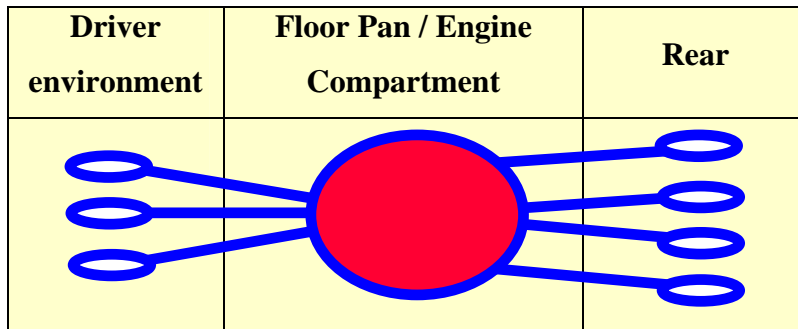


Figure N°4 - PF at the beginning of the project : A Combination of Modules

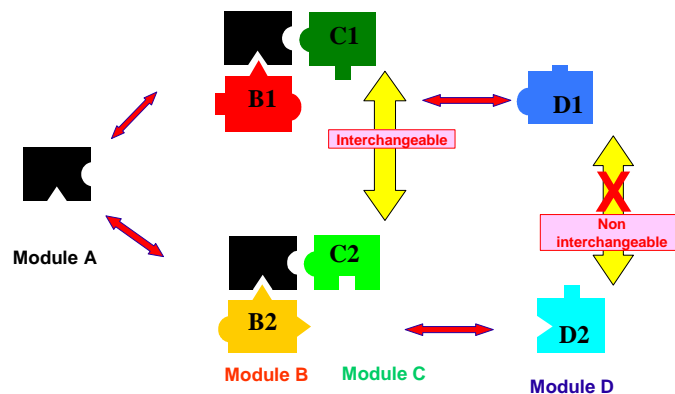


Figure N° 5 First stage of the design process

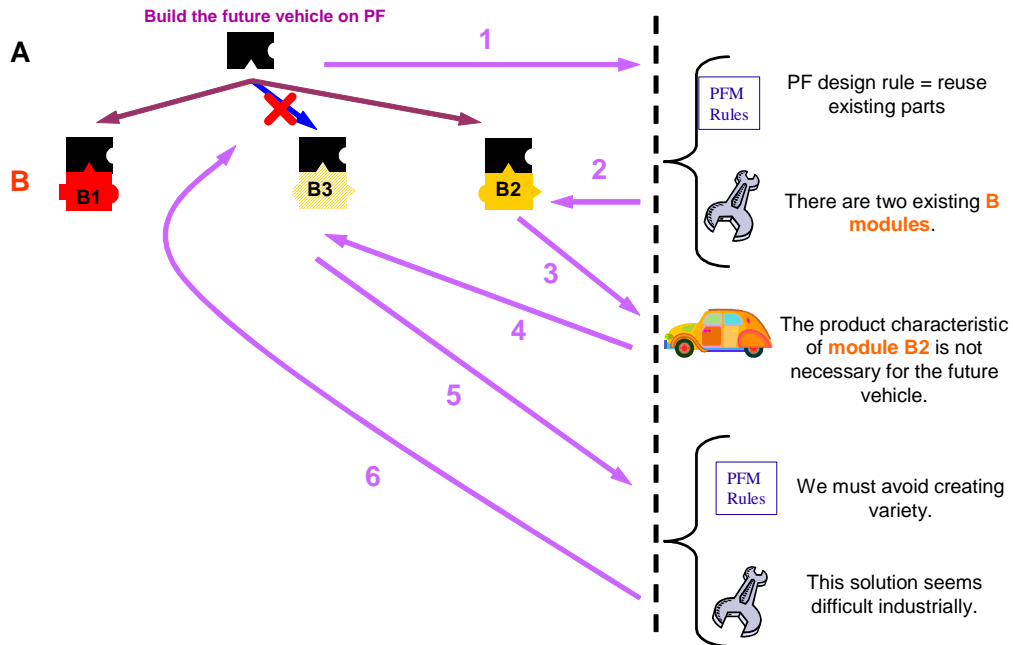


Figure N° 6 Second stage of the design process

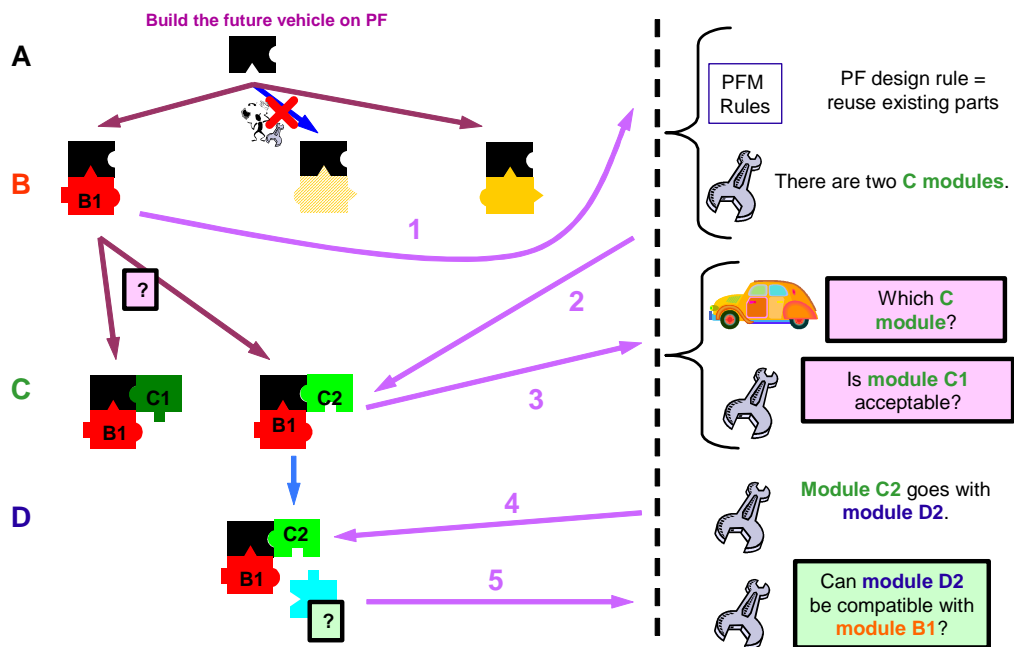


Figure 7: Third Stage of the design process

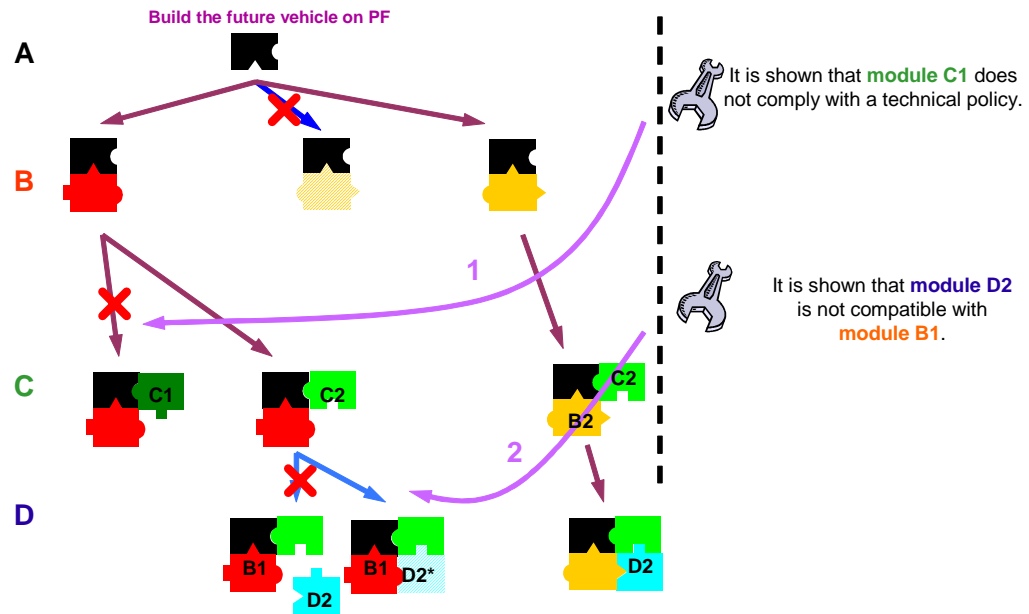


Figure 8: Fourth Stage of the design process

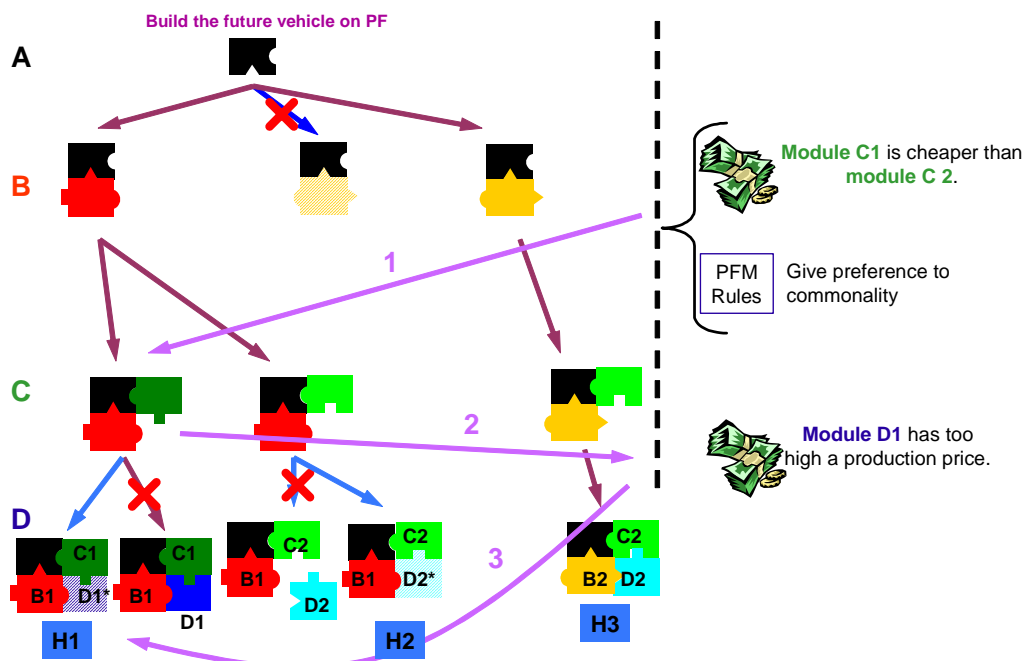


Table 1 : Evaluation of the three designs

Criteria	H1	H2	H3
Product			
Style	+	++	++
Performance	-	+	++
Product characteristics	+	++	-
Platform			
Technical impact	-	+	++
Industrial	++	+	-
Production cost	++	-	+

Figure 9: Fifth Stage of the design process

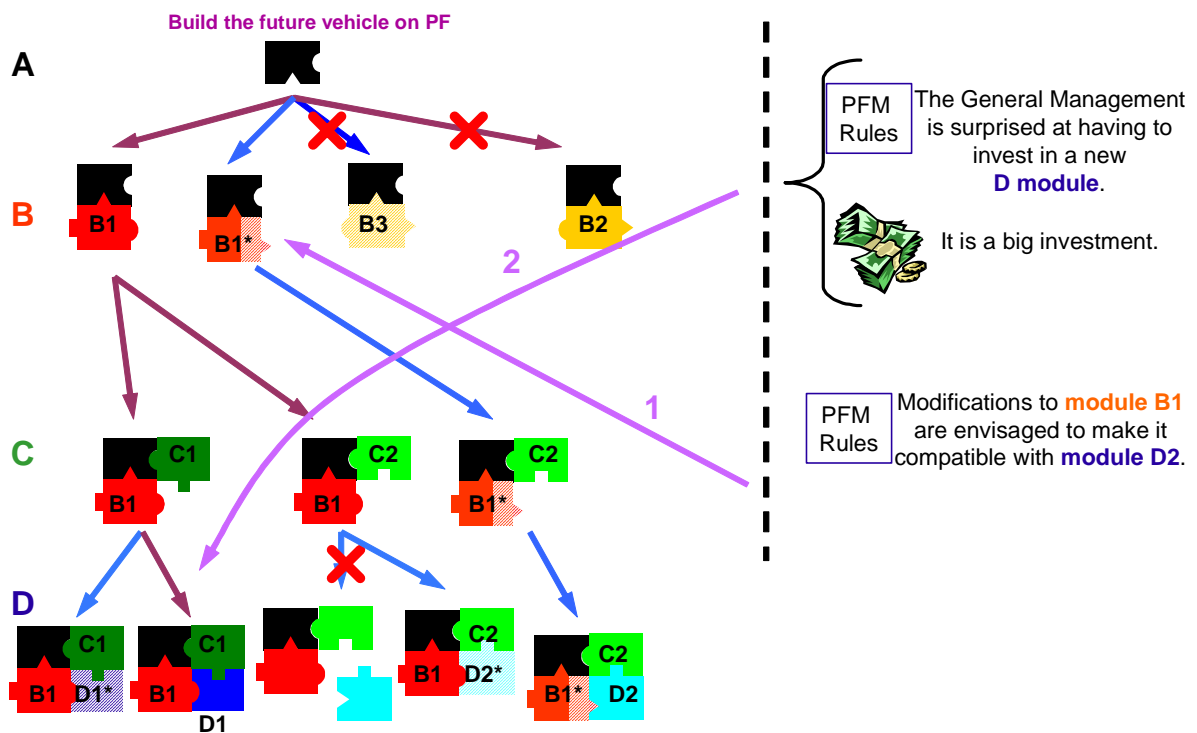


Figure 10. First Example of Platform Design Rules being Challenged

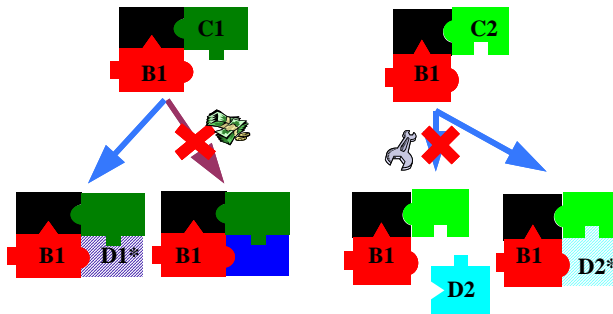


Figure 11. Second Example of Platform Design Rules being Challenged

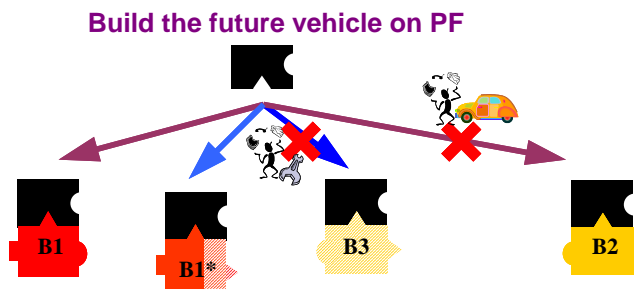


Figure 12 Traditional design and design in a platform-driven environment

