PLATFORMS FOR THE DESIGN OF PLATFORMS: COLLABORATING IN THE UNKNOWN

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1- Introduction: platforms for platform design

This chapter explores how industry platforms can be designed using specific collaborative relationships that also take the form of platforms. In several sectors, the architecture of industry is tending to loosen or even disappear: 'smart grids' in electricity supply, bio-materials and home networking in telecommunications and consumer electronics are all examples of new industrial contexts in search of industry platforms. In such situations, who is the industrial architect? Who provides the industry platform? How do platforms emerge and how do companies contribute to the process? What are the different forms of collaboration for designing industry platforms? Are there different contexts? Can we specify the circumstances under which it will not be one entrepreneur, or a series of individual entrepreneurs, but rather a coalition of entrepreneurs, who will attempt to create a platform?

Despite its importance, surprisingly little research has been done on platform design and the collaborative relationships involved. Industry platforms, particularly in high-tech industries, have attracted considerable attention since they induce seemingly anomalous strategic behaviour, competitive positions or pricing policies. Successful platform strategies have been identified in a number of diversified situations: PC architectures (Intel), operating systems (Microsoft), computer games (Sony, Nintendo), Internet browsers (MS Explorer), Internet search (Google) etc. Issues regarding platform leadership management and platform wannabe strategies are today widely understood, thanks to empirical studies and theoretical models. The works on the subject underline the importance of platform design in successful platform leadership but *have not really investigated the notion of platform design* as such. All the empirical cases and the related models of strategic platform management are based on a given platform potential, provided by a platform entrepreneur who may become the platform leader. The literature insists on the importance of a platform 'core', performing one essential function or solving one essential problem of the system, but how can this core be identified or designed? The works also focus on the optimal pricing taking advantage of cross-sided networks effects. But how can these networks effects be identified or even designed?

Moreover, what if there is no platform entrepreneur providing the platform potential? Companies working in highly innovative fields - such as 'smart grids', home networking or new bio-materials - are currently looking for platforms to help them organize industry growth or industry renewal. They can rely on internal platform entrepreneurship but they are also keen to work with other companies to design industry platforms in a kind of collaborative entrepreneurship. However, the challenges of platform design by a platform entrepreneur might be compounded for the collaborative partners designing the platform. For instance the issues of value appropriation and value sharing are more likely to block the collective design process. How can collaborative processes be organized and who should take part in them? What inputs, activities, phases and outputs are involved, and how can their performance be characterised?

It is interesting to note that these collaborative partnerships for platform design can share features with 'classic' industry platforms, in the sense that they support collective efforts around a collective core, organize networks of stakeholders and create value for all the members. However, contrary to the usual view of product platforms, they can *not* consist in the shared, core features of the future system since not only the components, but also the architectures, the customers, the partners, the performances, and even the business models of the future systems are still to be explored.

We shall explore the issues raised by these collaborations for platform design using a multiple case study in four different industries: bio-materials, microelectronics, aeronautics and biotechnologies. In all four cases, we had the opportunity to follow a platform design process on a longitudinal basis.

The emergent theoretical framework suggests that the collaborations for platform design *consists not only in delivering an industry platform but in positioning this platform potential into a strategic landscape, characterized by alternative platform strategies, the capabilities enabling these platform strategies and the values of these platform strategies for the partners.* To achieve this objective, collaborations for platform design have to deal with three main processes:

- Managing value creation, in order not only to identify a product platform for the industry but also to evaluate this platform compared to other alternatives and to integrate all the possible alternatives into a strategic mapping process.
- Organizing knowledge production and learning, by involving partners, offering support for various experiments and providing specific knowledge production devices.
- Managing the interests of each of the partners, by simultaneously creating value at the industry level and increasing the value of the partners' assets

This research suggests four research hypotheses:

1- The platform design process is neither an aggregation of past experience (Moore, Louviere, & Verma, 1999), nor a functional, so called 'top-down' design (R. S. Farrel & Simpson, 2003), nor an evolutionary adaptation of previous platforms (Gawer & Henderson, 2007; Meyer, Tertzakian, & Utterback, 1997). On the contrary, the design process is a structured exploration of alternatives driven by *common concepts*, *shared instruments for knowledge production* and a clear set of shared procedures for managing the collaboration common purpose. Hence the collaboration itself appear as a platform, using a well-identified stable core, gathering networks of partners who all value the core. Therefore we *propose to consider these collaborations as platform for platform design* (hypothesis 1)

2- Platforms for platform design and platforms for product/system design share common attributes but require distinct types of strategic management (hypothesis 2).

3- Platforms for platform design might perform better than platform entrepreneurs in situations with many unknowns (i.e. undecidability). This would reinforce the role of consortia, although they have often been considered as poor platform designers (Morris & Ferguson, 1993). It seems that conventional wisdom on the drawbacks of consortia (that they are complex, hence rigid and restrictive, and involve compromises) does not apply when the interests are unknown and discovered 'by walking' (Aggeri, 1999; Segrestin, 2005) and that the exploration and creation of interests can be enhanced through platforms for platform design (Le Masson, Morel, & Weil, 2007) (hypothesis 3)

4- Platforms for platform design have a strong impact on the evolution of platforms and open new horizons regarding classic issues of platform strategies: changing scope (Jacobides, Knudsen, & Augier, 2006), avoiding envelopment by changing networks (Eisenmann, Parker, & Van Alstyne, 2006), combining mobility and complementarity (Jacobides, 2006) (hypothesis 4).

The rest of the chapter is organized as follows: section 2 presents a short literature review of platform design and the issues raised by platforms for platform design; section 3 gives the methods and the data; section 4 presents the results of the multiple case study; based on theses results section 5 discusses the hypotheses, pointing out how they extend existing literature and offering some conclusions.

2- Literature overview: what has to be designed? How?

What has to be designed: the main features of an industry platform in the literature

How can the process of designing an industry platform be organized? The literature on platform strategy and platform engineering has focused primarily on the advantages of platform leadership and the issues involved, and hence underlined *what has to be designed* for being a platform leader and/or for efficient platform management. We can identify three main dimensions that several authors have considered as essential features of an industry platform: 1- a set of fixed attributes which are always present in the final system; 2- networks of platform users; 3- utility functions of the fixed attributes for the networks members.

In their definitions of platforms, several authors stress the importance of the first dimension, i.e. the set of fixed attributes that are shared by the systems built on the platform: Gawer and Cusumano and Gawer and Henderson (Gawer & Cusumano, 2002; Gawer & Henderson, 2007) define platforms as "*one component or subsystem of an evolving technological system, strongly functionally interdependent with most of the other components of the systems, and end-user demand is for the overall system*" (p.4). Bresnahan and Greenstein (Bresnahan & Greenstein, 1999) define platforms as "*a bundle of standard components around which buyers and sellers coordinate* *efforts*"; West (West, 2003) as an architecture of related standards (p. 1260). With the concept of 'modularity' (Baldwin & Clark, 2000, 2006), the fixed set of attributes is represented by 'design rules' that ensure the compatibility of the modules. From an engineering standpoint, "*a platform design consists of a basic architecture, comprised of sub-systems or modules and the interfaces between these modules*" (Meyer et al., 1997) (p. 91). Hence this basic core is not limited to a set of common components, technologies or subsystems but also includes compatibility rules that ensure that complements, modules and other systems are compatible with the platform. Note that in this perspective, the list of modules and complements is neither finished nor limited to 'standardized' components. Hence, the process of designing a platform consists in first designing this core.

The literature provides insights into the interesting economic properties of the core. As stated by Gawer and Cusumano(Gawer & Cusumano, 2008), it should bring value to the overall system ("*it should perform at least one essential function within what can be described as a "system of use" or solve an essential problem within an industry*") and enable innovation ("*it should be easy to connect to or to build upon to expand the system of use as well as to allow new and even unintended end-uses*"). It should also enable variety, low cost development, fast adaptation to evolving markets and option strategies (Baldwin & Clark, 2000, Meyer, 2002 #2016, Uzumeri, 1995 #1959).

The authors defining platforms insist on the importance of the second dimension of platforms, i.e. networks of platform users and their capacity to organize a "*collective endeavour*" (see Gawer in this book). This aspect of platforms is particularly underlined in the economic approach to platforms (Rochet & Tirole, 2003, 2004), where platforms are defined as "*double sided markets*". As explained by Eisenman et al. "*Products and services that bring together groups of users in two-sided networks are platforms. They provide infrastructure and rules that facilitate the two groups' transactions*" (Eisenmann et al., 2006). The definition of the networks can be more or less restrictive (Gawer & Henderson, 2007). The literature provides several cases where the platform user can be the owner itself (see Intel as a supplier of chipsets), suppliers (see the concept of modularity, the engineering platform perspective, etc.), content providers (see cases of double-sided markets such as Adobe, computer games, etc.), end-users, complementors, etc. Platform designing is obviously not limited to platform core design. The meaning of design is extended here to the design of all the attributes of the platform and is not restricted to *a priori* technical dimensions. Hence platform design also consists in identifying the actors that will be involved in the platform. Who are they and do they change over time?

The literature also provides insights into the 'good properties' of the networks to be designed. They should contribute to the development of innovative systems based on the platform; they should contribute to the platform financially, by buying the system or paying for using the platform; they should favour "*cross-sided network effects*" which appear because "*the platform's value to any given user largely depends on the number of users on the network's other side*" (p.94), hence creating increasing returns to scale for platforms (Eisenmann et al., 2006). Another issue is to extend the size of each network (Morris & Ferguson, 1993). However this extension should also be carefully tuned to control so-called "*same side negative network effects*" (Eisenmann et al., 2006; Parker & Van Alstyne, 2005), i.e. situations where new entrants to a network decrease the value of the network and threaten the value of the overall platform. This question of tuning network extension is widely debated in the literature, in a view to deciding how open platforms should be (West, 2003) and how mobility on one side can favour the other side or the platform (or architecture) leader (Jacobides et al., 2006).

The dimensions concerning products and networks are both linked to a third dimension, the values of the platform. This is a key point from the perspective of industry architecture: according to Jacobides et al. "*industry architectures provide two templates, each comprising a set of rules: 1) a template defining value creation […] and 2) a template defining value appropriation*" (Jacobides et al., 2006). As underlined by Gawer and Cusumano (Gawer & Cusumano, 2008), platform leaders' "*balancing act*" consists in "*protecting (their) source of profit while enabling complementors to make an adequate profit and protect their own proprietary knowledge*". This entails designing means of appropriation and incentives for commitment. For instance, Gawer and Cusumano mentioned that Google was able to create value through its search engine platform by inventing focused advertising. As underlined by (Jacobides et al., 2006), IP, the control of complementary assets, but also the control of asset mobility (limiting mobility on one's own side and increasing mobility on the other side) have to be designed by platform actors.

From this literature review we can deduce that platform design aims to define:

- a set of fixed attributes F_i, i=1…n, in which the attributes are subsystems, technology, system design rules, etc., and the set is fully or partly used to design systems S defined by a list of attributes S = {F_j, chosen in F_i, i=1…n; M_k} where M_k can be modules, complements, etc.
- a set of platform users U_j, who are members of one or several networks.
- a value function V_{Uj}, defined for each platform user, which defines the value that each user gives to the set of fixed attributes {Fi, i=1…n}. Note that the value function is based on Fi and NOT on S: the value depends on the expectations on all potential systems S and not (only) on the realized or simply already identified systems.

We have also identified the 'good properties' to be found in these elements: the economics of the design, innovation, increasing returns to scale through cross-sided network effects, industry leadership position, value creation at industry level, etc.

Gaps in the literature: how to organize the collective design of a platform?

How to organized platform design? Who can do that? Which capabilities are required? The issue of how to design these three dimensions of platforms has been addressed in two different types of literature, the first on the design of industry platforms and the second on the design of enterprise platforms.

The latter, which considers platforms that are mainly owned and managed by a single firm, focuses on the *platform core design*. It has identified three different platform design processes:

- a so-called 'top-down' or functional approach (R. S. Farrel & Simpson, 2003; Simpson, Maier, & Mistree, 2001). The design process consists in predefined linear steps, beginning with market segmentation, then defining the scaling variables and ranges to cover the market, then aggregating product platform specifications to finally develop the product platform. The process requires being highly knowledgeable about the future product family and markets, the technologies and product design principles, the architectures and the components.

- A so-called ‘bottom-up’ (R. S. Farrel & Simpson, 2003; Moore et al., 1999) or product consolidation approach. The design process begins with a list of existing products that have to be consolidated to improve commonality and economies of scale. (Moore et al., 1999) shows how to use conjoint analysis for such an consolidation process.
- A third approach assumes that the list of requirements, the architecture and technologies can change over time and are not fully predictable. Platform design is hence closer to a platform *redesign* process, where platforms are modified step by step over time (Meyer, 1997; Meyer & Dalal, 2002). For instance, the design can consist in a ‘platform extension’, i.e. in adding a new interface for a new module. It can also be a platform renewal where “*subsystems and interfaces from previous generations may be carried forward and combined with new subsystems and interfaces*”. This platform renewal process is a kind of *local search process* (trial and error by limited modifications to an initial solution) guided by indicators of product family performance, so-called platform efficiency and effectiveness (Meyer & Dalal, 2002; Meyer et al., 1997). We can call it an “evolutionary” model.

In the literature on industry platforms, we found very few models for the industry platform design process. Gawer and Cusumano (Gawer & Cusumano, 2008) evoke a model of platform design which we can call the model of the “platform entrepreneur”. The design process is divided into two steps:

a- First, a platform entrepreneur identifies a “platform potential” (p. 29), defined as follows: “to have a platform potential, research suggests that a product (or a technology or a service) must satisfy two prerequisite conditions: 1 it should perform at least one essential function within what can be described as a “system of use” or solve an essential problem within an industry; 2 it should be easy to connect to or to build upon to expand the system of use as well as to allow new and even unintended end-uses ». In the synthetic framework introduced hereabove, this means that this first step consists in defining the platform core, relevant networks and value models;

b- Second, a would-be platform leader (platform-leader wannabe) transforms the platform potential into an industry platform through “technology actions” and business actions”. It consists in defining, in precise terms, the actors of the networks and the value appropriation policy, and occasionally in modifying the core.

This model is in fact a good synthesis of all the examples found in the literature. More precisely, recent literature has made precious contributions to understanding the second step of the model. For instance authors provide rules to define optimal pricing and optimal openness (Parker & Van Alstyne, 2005; Rochet & Tirole, 2003) or insights to improve mobility and asset control (Jacobides et al., 2006). Gawer and Cusumano provide a further element for the second step: would-be platform leaders can be either in a platform ‘coring’ situation (no platform exists) or a platform ‘tipping’ situation (there is a platform war). The authors also point out that success in the second step largely depends on the first step (see Gawer and Cusumano). Several authors indicate that the obstacles encountered by a would-be platform leader might be overcome through *redesigning* the platform potential. For instance the risk of platform envelopment (Eisenmann et al., 2006) was partially overcome by

RealNetworks (Real) which managed to completely change the platform core and the networks, shifting from a media player software platform to an online subscription music service platform. The literature provides only very limited insights into the design process involved in this first step, i.e. the designing of a "platform potential".

The 'platform entrepreneur model' therefore raises two main questions that we will discuss below: 1- *What happens if the platform design process is not led by a platform entrepreneur?* 2- *What is the design process for platform potential?*

Gap 1: collaborative process for platform design

The first question appears to be a gap in the literature. Some authors (Morris & Ferguson, 1993) have proposed that the platforms resulting from a collective design process might be less efficient than those designed by platform entrepreneurs, since they "*settle on lowest-common denominator, compromise solutions*" and are often hard to change. This raises the question of the efficiency of the resulting platform and *the efficiency of the collective design process itself*. A large number of authors have investigated the issues raised by organizational situations where actors have to collaborate to develop standards in consortia (Leiponen, 2008; Zhao, Xia, & Shaw, 2007), to initiate cooperation for industry level innovations and to organize exploratory partnerships (Segrestin, 2005).

In this stream of research, a first approach studies a consortium as a decision making process whose final decision and decision duration depends on networks externalities (Arthur, 1989; Axelrod, Mitchell, Bennet, & Bruderer, 1995), on the "vested interests" of partners (J. Farrel, 1996), on the "commercial pressure" and the "tightness of Intellectual Property rights" (Simcoe, 2003). The decision also depends on whether the interest of users or the one of developers are predominant in the consortia(Chiao, Tirole, & Lerner, 2005). Zhao et al. show that the decision also depends on the potential conflicts between consortia participants, these conflicts being reduced when consortia begin early, ie before the formation of vested interests, or in situations like e-business where the platform link firms "which rarely compete directly with each other directly through standards" (Zhao et al., 2007). This approach actually considers that there exists proposed standard for well-identified networks (users, developers,…). The value of the standards might be known or only uncertain but there exists one or several propositions on which the participants will decide. Moreover participants know their interests. These interests might be more or less conflicting but each participant knows his own interest related to the proposals.

A second stream of research precisely discusses this hypothesis: the collaboration actually aims at creating new alternatives and the participants don't always know in advance what is there interest (Aggeri, 1999; Segrestin, 1998). The authors provide strong insights into what has to be managed in such situations: Aggeri insists on the management of *collective learning* in situations of shared uncertainties. Segrestin underlines that in such situations, cooperating actors have to manage both 'cohesion', i.e. *the emerging interests and possible common purposes*, and 'coordination', i.e. the *organization of the exploration process*. This raises the question of the processes involved in managing coordination and cohesion in the collective design of platforms.

This literature review provides us with a good framework for the analysis of collective aspects of platform design: 1- we will wonder whether this is more a collective decision making process on known alternatives by knows networks of participants with known interests 2- if not, we will pay attention to both coordination processes (phases, work divisions, resources,…) and cohesion processes (involvement, property rights, type of commitment…).

Gap 2: platform design process?

The second question, the design process for the "platform potential", is also a gap in the literature. It can be assumed that the designer of the platform potential, as an individual platform entrepreneur, uses processes described for enterprise platform design, namely "bottom-up", "top-down" and "evolutionary". However, such models are incomplete in the case of industry platforms since they do not address the issues of networks and values. Moreover, we have seen that bottom-up and top-down models cannot be applied in situations where future users, products and technologies are partially unknown. As a consequence, these models can only be applied in highly integrated, stabilized industries (one example is the historical IBM platform, as described in (Bresnahan & Greenstein, 1999)). However in more dynamic industries, only an evolutionary model could be relevant. Baldwin and Clark (Baldwin & Clark, 2000, 2006) provide certain elements for such a model at industry level: they show that modular operators can apply at the lower levels of the design hierarchy; they also underline that these operators can only marginally change the platform architecture, "*the design rules of a modular system, once established, tend[ing] to be both rigid and long lasting*". Hence the models of "product platform design" seem to be able to describe only very limited industry platform innovation.

Gawer and Henderson (Gawer & Henderson, 2007) actually help us to clarify this limit of industry platform innovation and the gap in literature. In their study of Intel platform extensions, they show that the process is actually driven by two critical issues: first, does the platform designer have the necessary capabilities and second, does the platform designer keep the existing architecture? Their study shows that platform design processes can cope with capability-building issues and can be driven by incomplete views of the future platform, to be completed at a later stage ("changing the platform/application interface without going into applications"). Hence there are two types of plaform design: using existing capability and existing architecture; or building new capabilities and exploring new architectures. Gawer and Henderson show that in the specific case of a platform entrepreneur like Intel, the firm in question finally developed platforms where it already had the necessary capabilities and focused on platform extensions that kept the overall PC architecture, i.e. questioned neither the notion of application nor the notion of chipset. It is also shown that the design process is a trial and error process. But generally speaking this raises the question of whether it is possible to imagine a platform design process which actually *favours capability building and broader explorations and occasionally revision of potential industry architectures*. A process of this sort could then generate and select platform alternatives without necessarily following a trial and error process.

This literature review on platform design has enabled us to:

1- clarify what has to be designed when designing a platform: platform core, platforms networks and platform values.
2- raise questions regarding gaps in the literature on the industry platform design process:
    a. Is there necessarily a platform entrepreneur or are there more collective forms of platform design? And more precisely: in case of a collaborative design, is it more like a negociation on known

alternatives, between known partners with known interests? Or do we find emerging alternatives, emerging partners and emerging interests? (gap 1)

b. Do such platform designer(s) *build new capabilities* and *explore wider changes in existing industry architectures*? If yes, what could be the model of such a strong exploratory, collective process for platform design? (gap 2)

3- Research methods and data

Given the limited theory and the goal of exploring organizational phenomena in a new context, we adopted an exploratory approach based on grounded theory-building (David & Hatchuel, 2007; Eisenhardt, 1989; Glaser & Strauss, 1967). The research method is an inductive, multiple case study. Multiple cases enable a replication logic in which each case serves to confirm or disconfirm the inferences drawn from the others (Yin, 2003). A multiple case study typically results in better-grounded and more general theory than single case studies (Eisenhardt, 1989; Glaser & Strauss, 1967).

The sample is composed of four cases of collaboration in platform design. To enhance the generalisation of the findings, the sample includes platform design in four different domains. Given the goal of understanding how platforms are designed through collaborative processes, this is a descriptive study requiring longitudinal research. The sampling focuses on collaborations that actually aimed at designing an industry platform, thus enabling us to study the early steps of the design process. We also checked whether these processes finally led to an industry platform, as defined by its core, its networks and values (see table 2 in Appendix).

The study has two main sources of data: archives and interviews. The archives include sources from the main partners in the collaboration. The interviews were semi-structured and focused on the main actors in the collaboration (see details in table 1 blow).

Table 1: Description of Sample Cases and Case Data.

Case name	Hemp	ITRS	Cockpit	Biotech
Domain	Biomaterials	International Technological Roadmap for Semiconductors	New civil aircraft cockpits	Biotechnology research platforms
Resulting industry platform	Professional rules for building with hemp for home construction	Production template for the next semiconductor generation	Validation bench for cockpit instruments	Set of routine services for bio-analysis, made available to researchers
Interviews	23 (hemp producers, transformers, users, architects, building material experts)	12 (engineers and ITRS delegates of semiconductor companies)	23 (main experts in cockpit design and aircraft integration)	18 (intruments users, owners and designers)
Detailed design reasoning	Whole process	Focus on specific design issues (two sub-cases: patterning and radio frequency front end)	Whole process	Focus on specific design issue (two sub-cases: imaging small animals and bioinformatics)

In order to monitor the design process, we used the most recent models of design reasoning (Hatchuel & Weil, 2003; Hatchuel & Weil, 2007, 2008), which generalize classic engineering design models (Pahl & Beitz, 2006) and search models (Hatchuel, 2002; Simon, 1969). This method helped us to rigorously identify the competencies used and created throughout the process and the various paths followed for different platform alternatives which emerged during the process. These representations of the collective design reasoning were built through archives and interviews and were validated by the main actors in the related design processes.

4- Result: a process of collaborative, exploratory design for platform

Case descriptions and analyses

We briefly summarize each of the four design processes (detailed presentations of the design reasoning are given in appendix, figure 1 to 3):

- Building with hemp: a hemp transformer became aware of several, uncoordinated initiatives to combine lime with hemp to obtain daub-like concrete. He organized an association "Building with Hemp" to bring together actors who were potentially interested in building with hemp, inviting architects, engineers, historians, lime experts, lead users and alternative associations defending sustainable development. Following the initial meeting, some of the actors met again to identify open questions on hemp building. A certain number of them realized that they could have long-term interests in such issues and decided to meet regularly. The central group of stakeholders decreased from several dozen at the first meeting to about ten after two of years. However, this group met regularly, sharing learning on new experiments and updating the agenda of open questions. The process served to explore several forms of building with hemp (renovation of historical buildings, a substitute concrete for alternative home building, the do-it-yourself market, etc.). In particular, the group applied for and obtained "professional rules for building with hemp" which enable builders to use hemp and provide ten-year guarantees for insurance purposes. These professional rules are the (first?) industrial platform for "building with hemp" (for a more detailed description, see (Caron, Barbier, Le Masson, & Aggeri, 2008; Garnier, Nieddu, Barbier, & Kurek, 2007))
- ITRS: the International Technology Roadmap for Semiconductors is a worldwide consortium that organizes regular meetings (three per year) of the main players in the semiconductor industry. At these meetings, semiconductor manufacturers, process machine suppliers and semiconductor users discuss and update the technology roadmap for evolutions in semiconductor processes. They identify open questions and synthesize available knowledge on all the emerging technologies and regularly deduce the template for the next generation of semiconductor processes. One result of their work is therefore the continuous redesigning of the platform for semiconductor processes. Hence this is actually a sequence of industry platforms.
- Cockpit: to innovate on civil aircraft cockpits, a cockpit supplier launched an in-house innovation process to design alternative cockpits. One of the alternatives gave birth to an original cockpit simulator that was used to work

with aircraft integrator designers, aircraft companies and pilots. The partners worked together to explore and refine the cockpit concept by combining it with aircraft properties, innovative exploitation strategies and new ways of flying and "governing" aircraft. The results of these simulations were discussed with the main actors (in particular the aircraft integrator) and gave birth to a new cockpit validation platform (first industry platform). The simulator was also used in a second step to design a platform for cockpit mass-customization, developed jointly with a business jet manufacturer (second industry platform)

- Biotech instruments: a group of scientists pioneering a new research field and instrument managers in a research institute used a new instrument concept - devised by an instrument company - to design an original facility for their research experiment. After a first success, they offered the research community access to their facility for original research programs. They selected projects which were relevant to the new research field and to the new instrument. The instrument maker was invited to follow and occasionally contribute to the experiments (free of charge). It helped him to develop a new instrument. The experiments finally led to the design of routinized measurement and analysis services, based on commercially available instruments. These services are a platform for the production of knowledge in biotechnologies (for more detailed description, see (Aggeri, Le Masson, Branciard, Paradeise, & Peerbaye, 2007)).

To analyze the design process in each of the four cases, we described the four cases following the classic descriptors of a managerial process: input, outputs, actors, capability creation, phases, coordination mechanisms, resources and property rights. The results are synthesized in Table 2 (see appendix).

Common features in collaborative platform design process

In all cases we can actually distinguish three interrelated processes:

1- Value creation management (cognitive framing): the collaboration begins by a shared *question* about a future industry platform. The process is then characterized by two concurrent moves. On the one hand, a refinement process shapes more and more details and builds more and more capabilities that appear to be useful for the final industry platform. On the other hand, the person or body in charge of managing the collaboration also undertakes a 'divergence process' aimed at regularly identifying platform alternatives, close to or far from the dominating design path. This is done either by simply using any newly produced knowledge (discovery of deviant uses, of surprising technology performance,...) or by launching specific investigations in new directions (organize the exploration of blue sky projects,…). The process serves to explore different and occasionally surprising aspects of what will make value on the final platform, and for whom. For instance, in the case of building with hemp (see figure 1), three means of obtaining value were investigated: hemp for renovation (value for specialized builders and architects), hemp as a substitute for concrete in traditional building materials (potential value for a large number of builders); hemp for 'do-it-yourself' applications (value for retail stores, materials and process suppliers). At first view, the divergence process slows down the overall design process, as it disturbs, influences and criticizes the dominating path. However, it actually contributes in *designing the value landscape* (Baldwin & Clark, 2000; Levinthal & Warglien, 1999; Thomke, Von Hippel, & Franke, 1998) on which the final platform will be based. It therefore increases the relative value of the final solution. Moreover, it paves the way to other platforms, exploiting other niches of the value landscape. The value management process takes the form of steering committees, which clarify the value landscape, the open questions and the platform alternatives. Note that it confirms the result of (Levinthal, 1997): the process is organized to increase "long jumps" on the fitness landscape to increase survival in the face of changing (or generally speaking: unknown) environment (see p. 945).

In a nutshell: the value management process is NOT only a decision process to lead people agree to choose on platform in a a fixed set of well-identified platforms alternatives; it is more a cognitive framing process, in which the actors are ready to explore several business conception alternatives and can strongly rediscuss the established business architectures. This cognitive framing process contributes to value exploration and hence value creation. It actually mixes *a development process* ("exploitation") and *an exploration process.* It finally led to an industrial platform (with all three dimensions: core, networks and value) but also to other outputs: platform alternatives, a mapping of the related value landscape,…

2- The organization of knowledge production (capability building): one of the inputs of the collaboration is the *identification of missing knowledge and capabilities* (this identification actually takes place throughout the design process, as proved by the numerous steering committees listing open questions). In parallel, some of these questions are investigated. The results are synthesized and shared, at least partially, with the other players. The investigations can be 'wild' and scattered, in particular when several players are interested in pursuing the explorations (see some phases in hemp and ITRS, see figure 3). They can also be highly organized when no single actor is prepared to investigate, or when the investigations cannot be made by a single actor (see knowledge production on uses and ways of piloting in a new cockpit, which required the involvement of the cockpit designer, the aircraft integrator and some pilots), and/or when the investigations require specific collective investment in knowledge production instruments (see the experimental facility in biotech, or the simulator in the cockpit case). Note that knowledge produced in this process is not necessarily fully shared between all the participants. It can even be partially appropriated by the knowledge producer (see Intellectual Property policy). Note also that the knowledge produced is always restricted to some aspects of the final platform (a key technology, one user,…); the new knowledge and capabilities have then to be integrated into one or several "platform candidate(s)" (eg. Cockpit designers will learn on pilot uses in specific context but the industry platform will also have to integrate some engineering constraints…). Hence knowledge production is *divided between platform members*; and this division, far from being a pure trial an error (where each partner would try one specific platform candidate in the hope that she will hit the winning one), requires a strong integration process that makes sense of all the knowledge provided by the participants. This is precisely the role of the value management process, mentioned above.

In a nutshell, the knowledge management process is NOT (only) a knowledge sharing between the actors of the process but it is a capability creation process. The knowledge creation process mixes *competitive knowledge production* (competitors can concurrently and competitively explores technical alternatives, the results being shared with the other explorers) and *collaborative knowledge creation* (knowledge creation facilities enabling the actors to collaborate to produce knowledge together).

3- The organization of partners' involvement. Involvement is a key issue throughout the platform design process as the list of partners evolves constantly. Two types of partners can be identified: those taking part in the value management process and occasionally in the knowledge production process; and those who only take part in knowledge production (e.g.: in the case of the biotech platform, the pioneering researchers and the instrument managers fall into the first category whereas the temporary users of the experimental facility fall into the second). The first have interests in the process and contribute to building the value landscape; the others may only be interested in one piece of knowledge resulting from the exploration or may contribute towards a very specific piece of knowledge only. Their involvement in the value management process is impeded by the fact that they are specialised in one specific asset, thus leading to too restrictive an approach to the final industry platform (see technology suppliers in ITRS, component suppliers in cockpits, instrument suppliers in biotech). Although such actors could quite legitimately refuse to contribute when they are not involved in value management, why do they in fact take part (and even pay for doing so, as in the case of the instrument makers in the biotech case)? First, because knowledge production is a very strong way of influencing the process in situations where there is a general lack of knowledge; second, because the knowledge produced can be of direct interest to them, even if the final platform does not fully fit with their assets (e.g. the instrument maker was able to discover new needs for researchers and thus to adapt his offer accordingly).

In a nutshell the involvement process is NOT limited to gathering the well identified actors of a stabilized sector but it regularly changes the perimeter of the collaboration. The involvement process mixes *aggregative process* (add new members and new networks of members, occasionally far from the initial sector or "deviant" from the main design path) and *segregative processes* (select preferably the members who are not stuck in one platform alternative but have interests in exploring several alternatives).

Fundamentally, this study provides results on our three main gaps in the literature:

a- it confirms that collaborative design of a platform is possible: the four cases show situation where collaborative design leads to the design of an industry platform; it also shows that the design process doesn't consist in organizing negociations on known alternatives, between known partners who know their interest (see gap1). Actually *alternatives, partners and interests emerge during the design process.*

b- It actually implies strong capability building and wide exploration of platform alternatives, including severe revisions of existing industry platforms (gap 2). It gives strong insight on the overall design process itself: the three processes (cognitive framing, capability building and people involvement) show that this is neither bottom-up (synthesize known alternatives) nor a top-down process (optimize the fit between building blocks and functional requirements) nor trial and error process (try platform alternatives to finally select the best one). Interestingly enough we find *a process that constantly balances the convergence towards an industrial platform and the regular opening of new divergence directions* (emerging platform alternatives, blue sky projects, involvement of new "deviant" partners…).

5- Theoretical proposition and discussion: the notion of platform for platform design

These results lead us to present and discuss four hypotheses on collaborations for platform design.

Hypothesis 1: collaborative design of a platform as an original form of platform

A striking result is that the output of the process is not only one platform potential but several. Moreover all these platforms are related to capabitlies, networks and value proposition for the network members. Hence, these platforms actually map a value landscape that was not here at the beginning of the process and is also a result of it.

These results lead us to consider that collaboration for platform design actually *aims not only to deliver an industry platform but to position this platform potential into a strategic landscape, that results from the exploration and includes platform candidates, i.e. alternative platform strategies, with their related capabilities, core, networks and value functions.* The collaboration actually designs *several* industry platform candidates and the related value landscape, and selects one of them in a short term but actually work on several of them in a longer term (see sequence of platforms in ITRS, in cockpit, see figure 2 and 3). This design process involves a wide variety of actors who ultimately find an interest in the exploration process and not necessarily in the 'final' industry platform. Just like an industry platform doesn't aim at developing only one single system S but several, the collective platform design process doesn't aim at providing one single output (ie industry platform) but several (several industry platforms, capabilities, clearer picture of the industry value landscape,…).

Hence we are driven to propose the following theoretical statement: a collaborative process of platform design can actually *be itself a specific platform*; we will call it a "*platform for platform design*".

Hypothesis 1: platform for platform design vs platform for product/service development

For such a platform, we can describe what makes "core", "network" and "value". IN each case we will underline where are the similarities and differences with "industry platform" ie platform for product/service development.

- Core: the core of a platform for platform design relies on three main dimensions: 1- the structure of all the industry platform alternatives and the related value landscape that they embody (eg. structure of alternatives in ITRS, in cockpit, in biomaterials…); 2- the knowledge production devices that are specific to the platform (see simulator, experimental facility, etc.); 3- the collaboration protocols that support value management and knowledge creation (agenda, pace, organization and composition of steering committee; rules for exit and entry…). This core contributes to the design of several platform candidates. It appears like a "platform generator" just like the core of an industry platform appears as a product generator. This platform generator doesn't only work for once but can be used several times.

- Networks: the networks of a platform for platform design consist in all the contributors to the exploration. One feature is that only a limited number of actors in each network will contribute, but several heterogeneous networks can be represented. The number of networks involved can be far higher than the number of networks using the final industry platform (illustration: in building with hemp, architects were involved in the exploration process but are hardly interested in the professional rules; in ITRS a technology supplier can participate to the exploration but excluded from the next generation industry platform… and compete for being in the following one). The classic industry platform is segregative in the choice of participating networks (usually a "buyer" network and a "seller" network) and then aggregative (to a certain extent) in the involvement of the members of a chosen network to maximize network externalities. On the contrary the platform for platform design is aggregative regarding the nature of the networks (seeking variety in committed networks) and segregative regarding the few people representing each network in the design process to keep only the members ready to produce and share knowledge between networks, to maximize learning externalities.
- Value: the value delivered by a platform for platform design is not limited to the value of the final industry platform (i.e. the value created by all the products based on this platform). The first value created is the value landscape itself, i.e. all the potential sources of values, whether they are integrated into the final platform or not (strategic overview in ITRS, biomaterial, ITRS and cockpit). The second value created is the knowledge that will be useful for the actors, even if this knowledge is not used in the final industry platform (eg. trials on cockpit revealed knowledge on piloting, on man machine interfaces, on users, that will be used by industrial participants). Hence, a platform for platform design creates externalities which are internalized by the platform partners (whereas an industry platform internalizes externalities generated by the networks). The third value concerns the specific knowledge that could not have been produced without the platform, i.e. through knowledge production processes resulting from the collaboration of two otherwise separate actors. Whereas an industry platform is characterized by a cross-sided network effect, a platform for platform design is characterized by a cross-sided learning effect, i.e. the learning on one side is considerably enhanced by the knowledge provided by the other side (and vice versa). (eg. experience on cockpit with aircraft integrator, suppliers, aerial companies and even pilots)

These results and the comparison between industry platforms and platforms for platform design are summarized in the Table 3 below.

Table 3: Platform for Platform Design versus Industry Platform

	Industry platform	Platform for platform design
Core	One core for multiple final systems. Core = fixed attributes of the system Core = maximize the value of the resulting systems (max. profits)	One core for several industry platform candidates Core = value landscape + knowledge production devices + protocols, Core = maximize the knowledge on the value of the resulting platforms, i.e. maximize the exploration of the value landscape

Networks	Segregative in the choice of networks (generally speaking: two networks) Aggregative inside the networks (maximize network externalities)	Aggregative for the networks (many heterogenous networks possibly interested in the future platform(s)) Segregative for the network representatives (only the most exploratory partners; maximize learning externalities).
Values	Platform users' externalities integrated by the platform. Cross-sided network effects	Platform externalities integrated by the platform users. Cross-sided learning effects.

This new notion of platform for platform design opens two main areas of discussion: 1- why and when actors wishing to design a platform would favour a platform entrepreneur strategy or a platform for platform strategy? 2- How does the platform design process influence the final industrial platform?

Hypothesis 3: conditions for choosing a platform for platform design.

As mentioned in the literature review, certain authors have underlined the limits of collective platform design (Morris & Ferguson, 1993) and others have underlined the difficulties in managing exploratory partnerships (Segrestin, 2005). One main reason to favour platforms for platform design is therefore simply that the platform entrepreneur strategy might be impossible! In this event, three conditions appear to favour platforms for platform design.

First, platforms for platform design are interesting in cases where the design is impossible without the contribution of a partner to provide new capabilities. For instance, in cases where the industry is changing drastically and the industry architectures are disappearing, the previous integrator can no longer manage the entire value chain and it is therefore interesting to spread the platform design capabilities between several partners. A first criterion is therefore*: platforms for platform design will emerge when individual actors lack some capabilities to design the platform and when none of the actors can create the missing capabilities without the collaboration of others* (criteria 1)

This first condition is necessary but not sufficient. In particular, if the value provided by the missing capability is clear to one actor, the latter could become platform entrepreneur and simply pay for the production of the missing capability (occasionally by sharing the related value). This situation is linked to issues such as complementary asset appropriation (Teece, 1986) and mobility enhancement (Jacobides et al., 2006): the platform entrepreneur strategy is possible in such cases (strong appropriation through integration or weak appropriation through mobility enhancement). However, the platform entrepreneur strategy is more difficult when the value of the missing capability is unknown. In this case, the debates on appropriation are weaker and collaboration becomes paradoxically easier. This is coherent with the studies of entrepreneurs in nascent markets (Santos & Eisenhardt, 2004) which show that entrepreneurs avoid 'ambiguity'. Hence platforms for platform design will appear in situations with 'unknown' value landscapes, where the ambiguity can not be easily reduced by a platform entrepreneur (criteria 2).

However, the situation with a lack of capability and a fuzzy value landscape may be very temporary, since the platform aims precisely to build capabilities and to design the value landscape. Consequently, a third condition of platforms for platform design is paradoxically to *maintain the lack of capability and the unknownes of the landscape* (criteria 3). This is not contradictory with the main goal of the platform and the paradox can be easily overcome: in the design process, capabilities are built but new gaps appear simultaneously; the value landscape is designed and clarified in some areas but this process reveals fuzzy borders. This third condition echoes the divergence/convergence pattern noted in the value management process.

To summarize, platforms for platform design will emerge in situation where *1- each actor lacks some capabilities and is unable to produce them alone; 2- none of the actors has a clear view of the value landscape, meaning that the value landscape has to be designed. 3- the design process itself creates capabilities and explores the value, it also reveals missing competencies and unknown areas in the value landscape.* It consists in balancing the realization (convergence) of a platform, and the unavoidable conflicts of interests between the exploration members, with a constant level of unknowness that keep a promise of benefits for all collaboration members.

These propositions are in line with results in the literature: Morris and Ferguson (Morris & Ferguson, 1993) as well as Farrel and Saloner (J. Farrel & Saloner, 1988) put forward that collaborative design of platforms is crippled by compromises made to find common agreements. Our work shows that platforms work precisely when the issue is not common agreement and compromise but the creation of common interests.

Gawer and Henderson (2007) showed that a platform entrepreneur such as Intel was able to design a platform where the firm had the relevant capabilities and the value of the platform extension was clear. Conversely, we found Intel involved in the ITRS consortium, in a situation where (1) capabilities were sorely lacking (what would be the processes and performances of the next generations of semiconductors?), (2) the value landscape was unknown in several cases (in these cases, it was impossible for the company expert to compare the value of two immature processes, which were yet to be developed), and (3) the uncertainty was never reduced. Note that the consortium recently faced great difficulties when the members debated on the opportunity to go for 450 mm process technologies: in this case, the value for the members was far clearer (Intel favouring mass production with 450 mm wafers, while other consortium members favoured more customized chipsets, with shorter batch sizes and smaller wafer diameters). The consortium resisted by opening alternative design paths to explore new areas of the value landscape (for instance, processes enabling 450 mm wafers with enhanced flexibility).

Lastly, these propositions also show that the conditions for platforms for platform design are in fact very demanding. They are hardly ever met in stable industries. This could explain why such processes have rarely been observed until recently. However, new emerging competitive situations could lead to the multiplication of platforms for platform design.

Hypothesis 4: specific features of an industrial platform resulting from a platform for platform design

The second issue to be discussed concerns the impact of this particular platform design process on the resulting industry platform. Do they differ greatly from platforms designed by platform entrepreneurs? We propose two main differences.

First, the resulting platform may be in a much better position to overcome the obstacles traditionally encountered by platforms: changing scope (Jacobides et al., 2006), avoid envelopment by changing networks (Eisenmann et al., 2006), combining mobility and complementarity (Jacobides, 2006), etc. When backed by the design platform, the industry platform can more easily develop new strategies on these classic issues. For instance, the first hemp platform based on professional rules for builders was able to change its scope by shifting to a platform for new 'do-it-yourself' business.

Second, the resulting platform shows more diversified forms of platform leadership. The platform entrepreneur model implies a strong link between the platform entrepreneur and the platform leader (see the Intel case). In our four cases, we found two types of industry platform leadership: a classic platform leader (cockpits) and platforms with collective leadership (ITRS, biotech, biomaterials). Strangely enough, the platform leader is not necessarily the main player in the platform for platform design: the cockpit designer had initiated and managed the platform for platform design but the company then gave the industry platform to the industry integrator (the aircraft integrator). This suggests that these platform design processes could pave the way to new platform leaderships: the platform leader might be the leader of the design platform, but the latter can also choose to delegate the industry platform leadership to one or several other actors.

Appendix

C-K diagrams show the main elements of the design reasoning for the different cases. In C, note how the different platform alternatives emerged; in K, the capabilities used to design these alternatives. Written in right on grey in K: the new capabilities built during the design process.

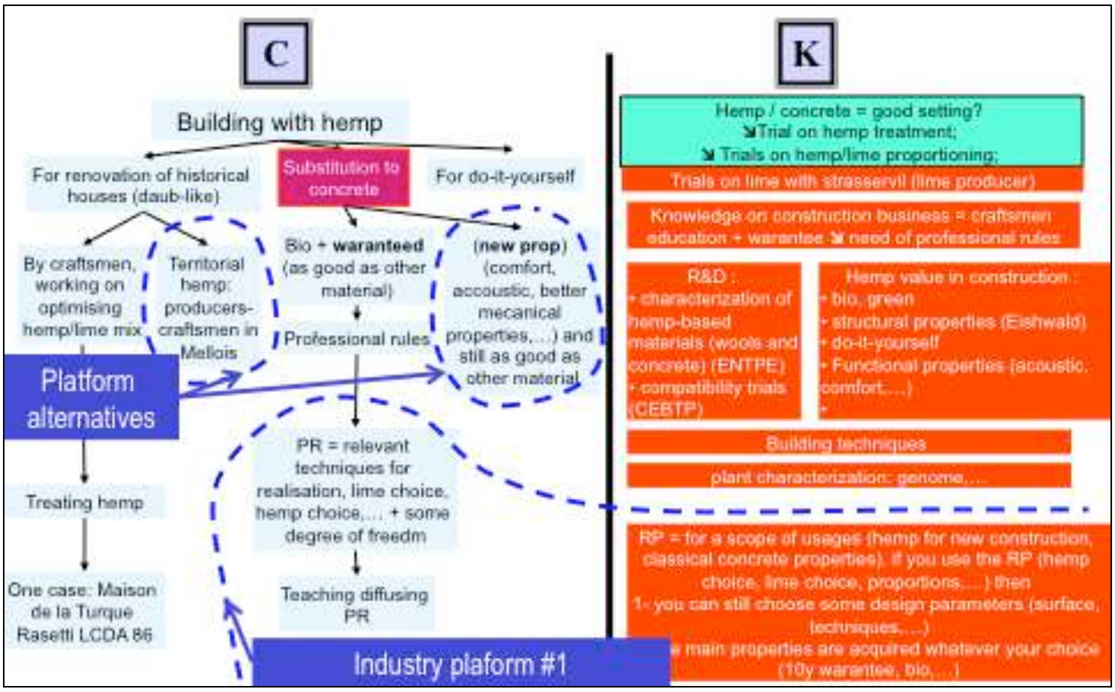

Figure 1: C-K diagram for the case “Building with Hemp” Case

1- the industry platform “professional rules for building with hemp” appears as a concept derived from the initial concept “building with hemp”, associated to new knowledge.

2- platforms alternatives appear beside the industry platform. They are candidates for future platforms.

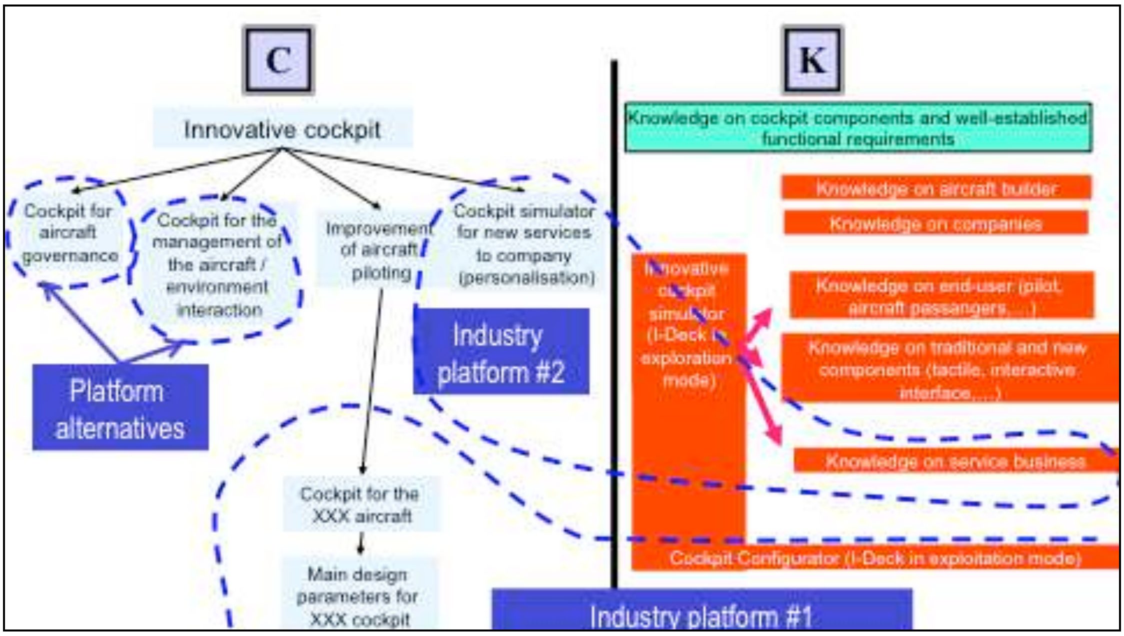

Figure 1: C-K diagram for the case "Cockpit"

1- the industry platform "cockpit for the xxx aircraft" appears as a concept derived from the initial concept "innovative cockpit", associated to new knowledge on cockpit configurations

2- a second industry platform appear beside the first one, on "cutomized cockpit for new services" also using new knowledge. Other industry alternatives emerge besides.

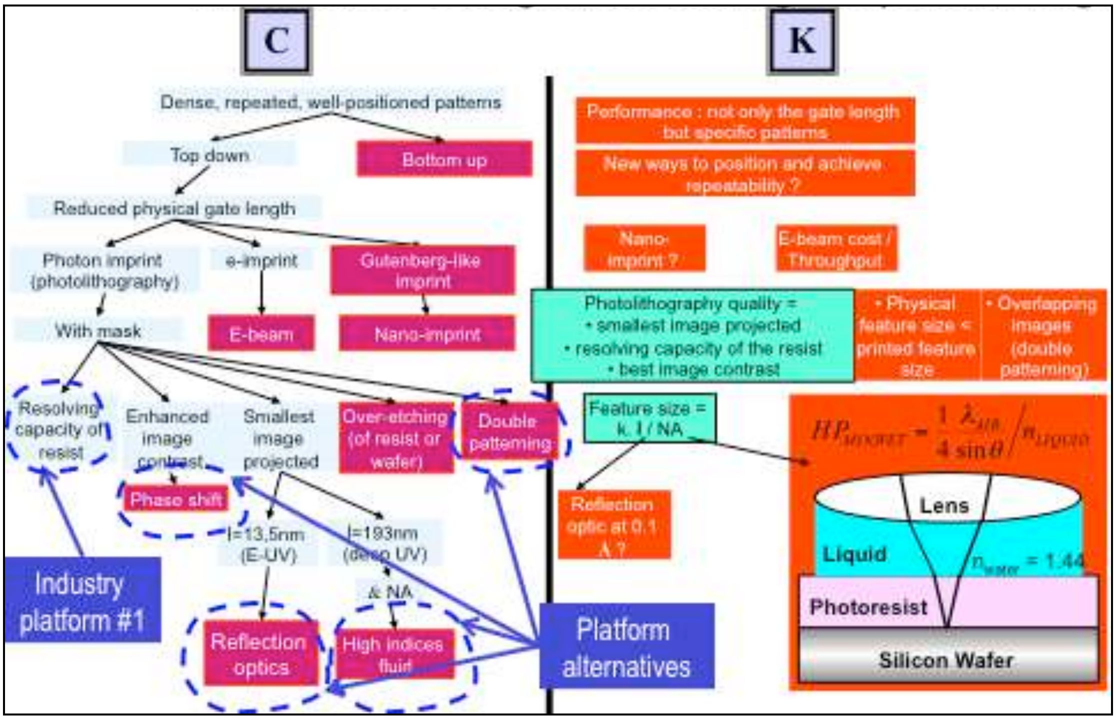

Figure 1: C-K diagram for the "ITRS" Case (special focus on "patterning")

1- the industry platform "resist" appears as a concept derived from the initial concept "patterning", associated to new knowledge on resists (material science, suppliers,…)

2- Several platform alternatives are also listed, as candidate platform for the future generations