Intensive Innovation Context and Design System Dynamics. The Case of Car Information Communication Entertainment (ICE) Systems

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Recent literature on innovation strategy and organizational change has challenged the classical punctuated equilibrium pattern (Abernathy and Utterback 1978) that alternates long periods of stability with short bursts of radical change in the dominant design of products. Research into high-tech sectors such as the computer industry (Brown 1997) and into the mass-production sector (Chapel 1996) has addressed the issue of repeated radical innovation trajectories and proposed theoretical patterns for «neo-industrial organizations» (Ekstedt and al. 1999), «intensive innovation-based strategies,» and «design-oriented organizations» (Hatchuel 1999, Midler 2002).

This chapter analyzes such ever-changing contexts. We try to demonstrate that such innovation trajectories cannot be analyzed as merely a succession of product projects, but rather must be tightly connected to deep transformations in the «permanent» organization where they are found. Our conceptual framework in analyzing such dynamics is based on the basic concept of *design system*, defined as consisting of three components (Mahmoud-Jouini and Midler 1999): the company's strategy, the knowledge/learning management system, and the project management process for new product development. Such a conceptual framework is very similar to the action/knowledge formation process theoretical framework for analyzing neo-industrial managing (Ekstedt and al. 1999). We will attempt to demonstrate how keeping track of intensive innovation trajectories over the long term requires the periodic reshaping of the design systems of a firm, and, consequently, leads to deep a renewal of such internal organization processes as reframing boundaries and relations with markets and other companies.

Our case study will examine a major European automotive supplier of car radio equipment that offers a paradigmatic case of major, repeated breakthroughs over the last four decades. The company we studied has, by dint of repeated and significant changes, managed to remain a worldwide leader in its field throughout the period in question. Its name and shareholders have changed on several occasions. The company has carried out numerous far-reaching internal reorganizations, and its relationships with automobile manufacturers have been similarly transformed.

In the first part of this chapter, we analyze the successive changes of the product, from the first car radio developed by the firm in the late 1950s, to ongoing new generations of «in-car, multimedia equipment.» These products involve technologies as varied as advanced radio systems, information technology, and GPS (global positioning systems), that provide services such as communication, navigation, security, and entertainment.

The second part of the chapter analyzes the various steps in the firm's evolution from initially being a spin-off a major European electronic company to redefining the customer interface to meet the after sales–OEM transition, internal organizational restructuring of product development and technology management, and financially merging with another major first-tier automotive supplier and service provider.

This chapter is based on a series of interactive research studies which began in 1994 (Kesseler 1998), (Midler 2000) (Lenfle and Midler 2002). These studies are part of a research program within the Centre de Recherche en Gestion de l'Ecole polytechnique on innovation strategy and project management which analyzes design system transitions in various industrial contexts (Benghozi and al. 2000).

Part One: The Product Trajectory: History and Characterization

There has been a series of major transformations in the world of car audio since the 1950s, in terms of technology, architecture, and functionality. Vacuum tubes have been replaced by transistors and integrated components, and software development have moved to the forefront. Architecture has evolved in terms of definition of internal electronics system components, the system/control interface, system integration into the automobile, distribution of components between those built into the system and those available via remote control. Functions increasingly removed from the original purpose have been incorporated, such as, CD and cassette players, telephones, navigational systems, emergency aid. Markets too have evolved, as distributor-based marketing to the consumer market has been replaced by the supply of premier equipment to manufacturers. Today, the simple act of naming a product, or even calling it a product rather than a service or system, is problematic.

1. From car radio to Information-Communication-Entertainment (ICE) systems.

The history of car radio began in 1929 with Motorola. Philips developed its first car radio in 1934. The technology, based on that of traditional radios, used vacuum tubes with all the associated problems of power supply and volume. As a result, the first car radios were of poor quality, hobbled by problems of interference, unreliability, bulkiness, and high energy consumption (see Appendix 2, Figure 1).

Until the 1970s, product innovations were mainly tied to developments in electronic components, notably the replacement of vacuum tubes with transistors in the 1960s (Philips introduced the first car radio to use only transistors in 1961). With this technological development, service quality improved while costs declined, and product architecture could be transformed so that all product functions could be incorporated into the standard-format «box» (see Appendix 2, Figures 2 and 3).

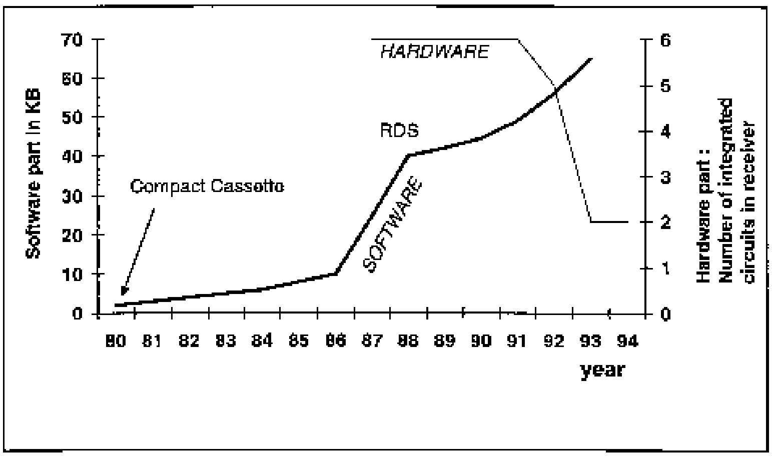
Beginning in the 1970s, the innovation dynamic accelerated and diversified (see Table 1 in Appendix 1). New functional improvements in radio operation were introduced, including digital displays, preset stations, RDS, and TMC. New functions were increasingly added to the basic radio function, functions such as cassette and CD players, GSM telephone/radio receivers, GPS-based navigation technology, on-board computers, and today, dynamic navigation, and Internet access. Car radios have been transformed into information-communication-entertainment (ICE) systems. Product architectures have also changed greatly. As chip-based components were integrated into the box, platform architectures could be steadily redefined and increasingly complex functions added without a need for more space or additional cost. Software then became more important, and the number of hardware components decreased (see graphics in Appendix 2). Finally, the electronics «box» became detachable from the faceplate , to provide enhanced security (removable front panels). The architecture transformation also involved the integration of ICE systems into the car. Increasingly, the box is no longer subject to the constraints imposed by standard formats and connections: e.g., steering controls and some information displays can be moved, front panel design can be integrated into that of the dashboard, CD changers can be located elsewhere in the car.

2. Description of the product trajectory

We will use four characteristics to describe the innovation dynamic for the product: technology, use functions, product architecture, and distribution methods.

A process based on rapid and far-reaching changes in technology

Clearly, technological advances, in this and other areas of the electronics industry, have driven the dynamic governing car audio products, including those of the electronics components (vacuum tubes, transistors, components, chips), communications protocols, and computer technologies that play an increasing role in car audio systems.



Transition from Hardware to Software
(Source: Kesseler 1998)

We will highlight three consequences of this well-known phenomenon of ongoing change in electronics and computer technology. First, the dynamic governing innovative product offerings in car audio systems is largely based on continuous cost reductions, the concomitant increase in system power, and the more compact size of new technology. This primarily applies to economic dynamics driven by product offerings. Next, the trend towards smaller size supports a system architecture dynamic that constitutes a major challenge for the various industry players. We will address this issue below. Finally, the permanent nature of these redefinitions ensures that, although electronics plays a crucial, strategic role for car manufacturers, they have never been able to master research into the field on their own (witness initial attempts that ended in failure). In the 1970s France's Renault, in particular, attempted to develop a subsidiary but had to abandon the idea because it was unable to maintain the appropriate electronics expertise in an environment of constant change.

Consequently, trends in car audio systems are primarily driven by companies providing electronics technology. This explains the current problems described in the next section, where we see that enhanced understanding of how products are used is increasingly essential to project success.

Constant changes in system architecture

Product architecture is another field marked by major changes, changes that fall into three categories: the architectural dynamic of the internal «box,» the architectural dynamic of integrating the system into the car, and the architectural dynamic of the relationship between integrated components and components outside the car. These three dynamics are closely intertwined.

Internal system architecture has been subject to two concomitant trends. The emergence in 1993 of the concept of the platform as a stand-alone technical entity provided a way to reduce technical diversity while maintaining the capacity to produce a wide range of finished products.

A trend towards modularization (Baldwin and Clark 1997) is gradually establishing an engineering architecture based on functional definitions, as shown in the figure below.

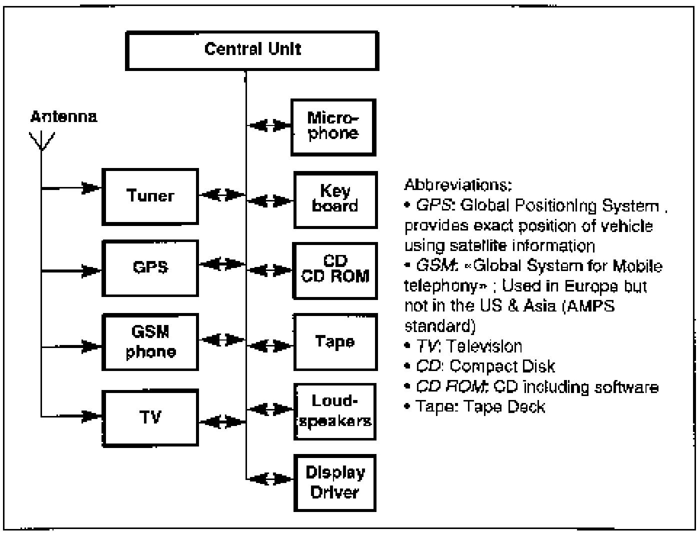


Figure 2: Technical architecture of an ICE system in 2001.
Source: Kesseler 1998

Architecture of the combined car audio/automotive system has been subject to three different trends. First was a trend towards the concentration/integration of technical components within the box, using a standard format and interface, a phase which finished in the 1960s. Then came a reverse trend towards relocating certain box functions elsewhere in the car, a process that began in the late 1980s, as, for example, radio controls were moved to the steering wheel, dashboard displays were converted to digital displays, technical functions were integrated into other locations in the car (e.g., tuners in the antenna, CD changers under the seat or in the trunk). At the same time, a trend towards stylistic integration of the system into the car's interior design was also evident.

Architecture between built-in functions and functions accessed remotely is a recent but important area of change. The available services are determined by the complementary nature of built-in functions (normally the radio receiver) and functions provided by outside service operators (typically, radio transmitters). This distribution of roles is undergoing major changes. Built-in functions that have so far been mostly passive (such as a radio receiver) are now becoming more active, so that users can define services (such as telephones or geographical locating services) based on information generated by the vehicle itself. As telecommunications data travels at higher speeds, a number of elements that in the past had to be stored in the vehicle itself, either physically or as software, could be moved outside the vehicle, such as CD ROM–based navigational media.

All of these major architectural changes have had profound effects in terms of value distribution and the relationships between the firms that design and operate these systems.

The functional dynamic

The following five points summarize the nature of this functional dynamic.

At the outset, an approach in which new usage indicators are adopted from fields other than the automotive field. The use of functional components is defined and understood outside the automotive setting before these components are adopted for use there. This was the case with the car radio itself as well as with cassette players, CD players, car telephones, and minidisk players. In this way, manufacturers can rely on the customer's previously acquired understanding of how the product operates. These components must be significantly adapted when they are imported into an automotive environment, so as to cope with vibration and interference, adapt to the ergonomic and safety requirements for their use with a conductor, select automatically the best transmitter frequencies (RDS), etc.

A major expansion in areas for exploration. Whereas initially only radio was involved, companies today define their field as one of information-communication-entertainment (ICE) systems. By bringing together tuner technologies (radio communications), GPS (locating systems), GSM (telephone services), television, processors, CDs and CD ROMs on a single platform, manufacturers have greatly enlarged the scope of potential uses for these systems, for purposes including navigation, tourism, travelling assistance, communications, and games.

Today, one of the major difficulties for companies in this field is to explore this burgeoning array of new functions, in areas that diverge from the traditional fields in which electronics engineers and manufacturers operate.

Accelerated creation of new usage indicators specific to the world of cars. In addition to this process of adopting functions from other domains, functions are increasingly being created specifically for use in automobiles. Navigational systems are the best-known current example of this, but other services to assist drivers include tourist guides, communication with manufacturer after-sales service departments, and fleet management.

The point we wish to emphasize is that, in the past, the adaptation of functions from other fields benefited from the fact that customers could apply skills learned outside the automotive setting. This considerably reduced the risks in assessing the value of these functions in the eyes of potential customers, and greatly accelerated the adoption of these functions for use in cars—i.e., no learning curve. However, this is decidedly not the case when it comes to entirely new functions. The significant learning curve required of customers today is a major obstacle to deploying new innovations in cars, since it calls into question traditional methods for marketing new products, which innately consist of building company notoriety and educating potential customers.

New competition between services integrated into the car and «portable» services. Along with this expansion in the number of fields to be explored, another notable factor is the emerging competition from portable products such as portable CD players, telephones, and notebook computers that provide users with capacities that formerly only built-in electronics could offer.

A redefinition of distribution methods with regard to innovation

At first specialized distribution channels were used for car radios. This situation changed in the 1970s: on one hand, the energy crisis of that decade led to the disappearance of most specialized dealers, while on the other, vehicle distribution networks demanded that car audio systems be distributed as an after-sales accessory (the Parts and Accessories business). Finally, in the 1980s, distribution via OEMs (Original Equipment Manufacturers) expanded, as car audio manufacturers shifted their sights from the consumer market to supplying products to car manufacturers. The table below indicates the spectacular growth in this market.

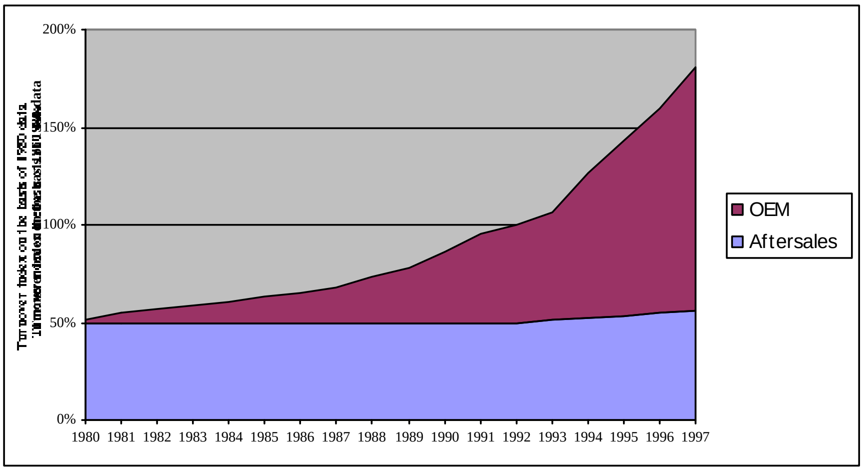


Table 1: Evolution of turnover of OEM and after-sales activity.
Source: Kesseler 1998

The growing significance of OEMs relative to after-sales service involved not only market share but also the role played in the innovation dynamic. Until the early 1990s, innovations were first tested in the after-sales department before being transferred to the OEMs. Today, this time lag is decreasing, and innovations are emerging among OEMs at an increasingly early stage (see figure below).

Table 2: Innovation trajectories in car audio systems.
Source: Kesseler 1998

	Home audio market	Aftersales	OEM
Stand alone system	**CD** (1979) → 1987 **DCC** (1994) 1994 → **Minidisk** (1994) 1994 →	In-car CD → 1991 **Quick out, Code Detachable faceplate** → 1990 DCC Minidisk Remote control ← 1993 Navigation ← AVC 1995	In-Car CD Quick out, Code Detachable faceplate **Integrated designed faceplate** **Remote control** **Navigation** **AVC**
Broadcast dependent systems	**RDS** ↔ 1985 **DAB** ↔ 1998	**RDS** → 1990 **TMC** → **DAB** 1998	RDS TMC

Boldface type: Initial marketing of the innovation
Regular type: Subsequent marketing

Part Two: The Innovative Firm Odyssey:
Design cooperation patterns and innovation management dynamics

The car audio «product» has been profoundly transformed several times over the past 40 years. During this time, the organization we studied has been one of Europe's leaders in the ongoing revitalization of car audio technologies, functions, and markets.

How has this firm been able to withstand the repeated crises arising from the successive redefinitions of the product? We will argue in Part Two that the firm's durability can be traced to its ability to redefine its design system to ensure that this system remains highly effective for the range of designs that arise from product evolution. We will break down this dynamic into four stages, and describe the salient aspects of the related design system model for each.

Stage One : Separate design, the importance of integrators and of standards.

The most notable aspect of the prevailing model during the early stages of car radio was that radio designers were distinct from car designers. The car radio seemed to be a variant of traditional radio products and was designed in the research centers of firms such as Motorola or Philips. The integration of the radio into the car rested on two avenues for convergence, one gradually replacing the other:

On one hand, there was the integrating player who would *complete the design of the combined car/car audio system, which was incomplete up to that point:* i.e., the network of specialty distributors mounting radios in cars. Until the 1970s, integration of the radio into the car was in the hands of specialists. This was partly a matter of physically installing the radio, antenna, and speakers into the car, but it also involved resolving the numerous problems created by interference generated by the vehicle's electrical equipment. Components had to be added to this equipment in order to eliminate static. In the 1970s, this integrating player would change: on one hand, the energy crisis of that decade led to the disappearance of most specialty craftsmen, while on the other, vehicle distribution networks demanded that car audio systems be distributed as an accessory (the Parts and Accessories business). At first, this transition was not a smooth one, as the network of car distributors did not have the electronics expertise to handle problems arising from the incorporation of radios into cars. But it had a major consequence, in that in the eyes of their customers, manufacturers, by virtue of their networks, became responsible for car radio performance. After-sales service gave rise to a design phase focusing on improving the compatibility of the car and its radio.

On the other hand was the emergence a gradual standardization process for the car's and the radio's functional and engineering specifications, *whereby each could anticipate the dynamic of the other without explicit coordination.* This standardization involved both the radio's design constraints to be observed and the evolution of manufacturers' car specifications, including integration of the DYN format into the dashboard design, interference suppression in electrical equipment, provision of necessary connections for powering the radio, and speaker and antenna prewiring.

2. Stage two: the development of OEM products and platform-based design

OEM[1] distribution would clearly pose a significant challenge in terms of design. Whereas, under the previous model, the radio was integrated into the car after production and sale, now this step could be taken beforehand. The key notion behind this second stage is one of a «fully equipped car.» This means offering the customer a level of quality newly validated in the prototypes, at an attractive price that takes into consideration the cost of incorporating the radio mounting process into the production line.

However, it should be noted that this model was still far from the comprehensive design of a car with built-in radio. As was generally the case at the time, the relationship between the car manufacturer and the supplier was primarily driven by the manufacturer's purchasing department and the supplier's (new) OEM sales department. There was little cooperation between the engineering departments of the two firms.

For the manufacturers of car audio equipment, this new distribution channel represented both a major growth opportunity and a new factor to be adapted to. Car-manufacturing customers attempted to impose particular specifications for their product ranges and the array of specifications exploded. The concept of a platform was to become the means of integrating this new diversity while preserving the economies of scale that are essential in the electronics field. In 1993, the studied firm grouped its products into families: one up-market product line, two mid-range lines and two low-range lines. In a still later generation of products, manufacturers could concentrate on just two platforms—high-range and low-range—that generated all OEM and after-sales products.

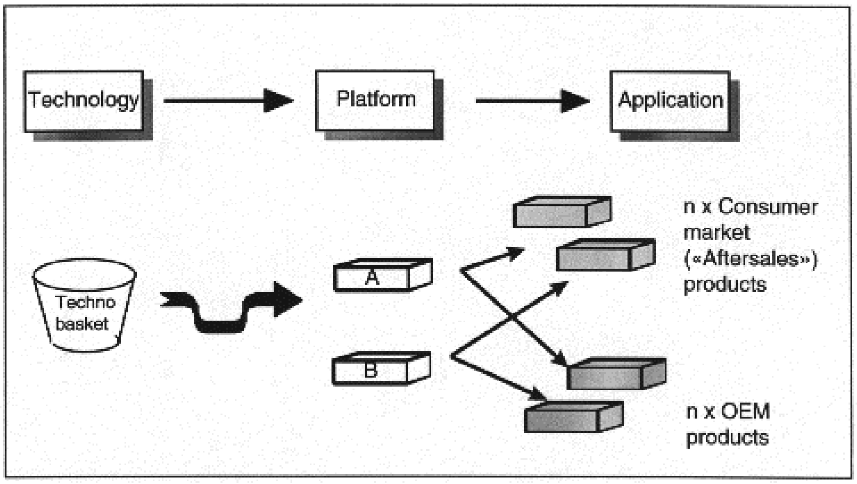


Figure3: The three-step model of technology integration.
Source: Kesseler 1998

3. Stage Three: The co-development of the joint car/ICE system.

[1] On the French market, the first car radios marketed by OEMs with new cars appeared in 1981 for Renault and in 1989 for Peugeot.

A third phase, initiated by car manufacturers, got underway in the early 1990s, with their development of enhanced project processes (Midler 1993). This development was to entail multiple changes in the design process, two of which should be emphasized. On one hand, there was a much greater need for integration among various project contributors, in order to arrive at a higher-performance and more stable design compromise, with a resulting cost reduction and shorter timeframe. One consequence of this strategy was to increase the power of suppliers as major players in the design of automotive products. On the other hand was a need to account for the distinct nature of each project, so as to enhance its differentiating value. Innovation plays an essential role in this regard.

The rapid increase in the power of these new key players in the manufacturers' design process was to accelerate in the early 1990s with the creation of relationships described in management literature as co-development (Garel, Kesseler and Midler 1997) or black box sourcing (Clark and Fujimoto 1991), triggering a crisis among suppliers involved in the internal OEM design model (Kesseler 1998).

The demands for innovation, specificity, and incorporation into the car ran up against the «push» engineering logic prevalent among suppliers (technologies—platform—product). The platform logic had the paradoxical effect of delaying the introduction of innovations in the OEM market, as neither the interface nor the supplier's internal organization provided a means by which project requirements could be redirected back to the designers who could address them.

Based on this analysis, in 1994 the studied firm undertook a thorough revision of its design procedures (Kesseler 1998). It created «Lines of Business» (LOBs) specific to each manufacturer, and having close engineering relationships with car project teams and provided with design and engineering capacities so that the product could be adapted to specific elements of each project. It reorganized the internal relationships between platform designers and LOBs so as to eliminate the inertia associated with this dual design approach and to allow those involved earlier in the process to incorporate the manufacturers' expectations more effectively.

Thus, three years after addressing this serious crisis, the firm was the first supplier to its major customer to obtain certification as a partner-supplier. Various products provide concrete evidence of this ability to incorporate a built-in system into the vehicle's design much more thoroughly (see Figure 4) in terms of design, controls, and functions.

4. «Co-learning» of innovative offerings in built-in services

The experience of the years 1990–1995 broadly validated the significance of this model but also revealed its limits. The framework governing development projects was too limited to allow for the exploration of truly new functions or technologies. In addition, the principle behind co-development was to create a cooperative design process addressing a defined functional target: the definition of this functional specification fell outside the scope of this process, and went back to the pre-project planning or research stages.

Co-learning: challenges and scope

During the second half of the 1990s, various pre-project cooperative design experiences were initiated, building in most cases on the success of prior relationships arising from co-development. Thus, in 1996, the studied firm created an entity of its own in cooperation with Renault, the «Multimedia Data Communications Planning Group,» whose purpose was to pave the way for the introduction of innovations in automotive projects.

We will define this approach as the *co-learning concept* (Midler 2000). The objective of co-development is to foster cooperation on a new product with the goal of enhancing the expertise of each partner regarding value-enhancing functional targets and the technical solutions with which they can be attained. Co-learning, on the other hand, is geared towards coordinating methods for exploring innovations and creating expertise regarding product use and technology that will prove useful in subsequent projects.

More precisely, co-learning can be defined as cooperation in three tasks:
- *Exploration*: In the area of built-in ICE systems, we have seen that the number of potential services has exploded, including services such as navigation, «low-cost» navigation, television, videogames, and the Internet. The first task of the co-learning process is to explore this growth as exhaustively as possible by monitoring advances in technology.
- *Sorting*: The second task is to sort through these potential services and identify pertinent innovations, with a view towards extracting the greatest value from the innovation, as defined previously.
- *Bringing these concepts or half products* (Le Masson and Weil 1999) *to maturity*: The third task is to bring the innovation to a mature form, so it can be incorporated into the project without unduly delaying the release of the final product or endangering production quality.

The challenge to the supplier and manufacturer as they carry out these tasks in cooperation with each other is, of course, to reduce costs as well as the associated risks of such early exploration. The compatibility problems that arise in the later stages of a project, when supplier and manufacturer fail to coordinate on a «road map» in such a rapidly developing area, are significant, as is the risk of duplicate exploratory work.

We must emphasize the twofold aspect of this co-learning process: it simultaneously involves defining innovative functional specifications that have the potential for further development, and mapping out the technological path by which they can be given concrete shape.

New participants in the co-learning process.

One consequence of defining this learning field is the need to open up the co-learning process to new players essential to ensuring the success of the tasks defined above. Such players include the service operators who will invent innovative content built into these systems, and distribution networks, which play a key role in Stage One but whose role in design all but disappears thereafter.

The involvement of service operators. In October 1997, the studied firm, which was a subsidiary of major electronic group, was transferred to a German group, one of the largest telecommunications firms and service providers in Europe. The firm contributed its terminal expertise to link automotive systems to the network offerings and services of its new owner. The German group is a European manufacturing firm active in dashboard instrumentation, a field in which the studied firm had no presence, so this step was consistent with a move towards reconfiguring ICE system architecture within the automotive cockpit module as well as between cars and external service providers. This consistent approach was not to survive the battle over portable telecommunications among firms in the field. On being bought out by one of its competitor, the German group was forced to sell its auto subsidiaries in order to finance the growth in GSM. They were purchased by Siemens, another major electronics firm, but one lacking experience in service. Note that this story is not an isolated example of cooperation between telecoms and automotive firms: for example, in 2000, PSA created a joint venture with Vivendi Universal to develop built-in data communication services.

The return of the distribution network as a key factor in innovation. We noted in the preceding section a trend away from the use of existing functions (typically radios and cassette and CD players) towards the creation of new functions specific to the automobile (typically navigation). The issue of teaching customers these new functions seems to be a key element in making these innovations succeed, as measured by the speed with which they are adopted.

Internal organizational dynamics associated with co-learning.

As in the previous stages, the implementation of the new co-learning model entails both a reorganization of the relationship between cooperating companies and internal transformations without which this relationship cannot function.

The primary trend on the part of manufacturers is to revamp their research departments, which have so far been only minimally integrated into the design operating cycle, and which are now assuming a role in the co-learning process.

On the part of suppliers, the organization into LOBs, which can naturally integrate these new areas of cooperation with manufacturers, must be thoroughly revised insofar as the challenge is now to provide direction for the general dynamic of the company’s product portfolios and technologies, rather than to customize «semi-products» (Weil 1999, Le Masson and Weil 2000).

Finally, the control of such learning processes calls for new management principles to meet the specificities of such projects (Lenfle 2001, Lenfle and Midler, 2001) : such projects do not lead to marketable products but new knowledge which only acquires value in product projects

Ensuring solidarity and equity to face the risk.

Co-learning brings a cooperative design process into play in an area where the level of uncertainty is considerably greater than is the case in co-development. The traditional problems relating to the theory of agency and contracts analyzed in the economic literature, problems such as moral hazard or adverse risk selection, play an important role. One significant problem, currently the subject of research, is that co-learning is spreading from the cooperative planning of isolated projects to the joint direction of project portfolios. The question of dynamic balancing of risk in this portfolio is obviously a critical stumbling point.

Finally, in order to keep the cooperation active and fruitful, the players involved in such co-learning situations have to evaluate and continuously control the process in terms of equity. In a co-development project, the cooperation can be clearly framed by the target of the common project and the rather explicit prior contract between the partners. Such framing is impossible in co-learning situation, because the results are multiple, indefinite, and changing, and the term of the relation unfixed. Cultivating feelings of equality among the players involved in the cooperation appears, therefore, to be a key and difficult challenge in co-learning situations. For Piron (2000, 2001) inter-firm equity comprises three ways in which justice or equity finds practical expression: distributive, procedural and interactive. *Distributive justice* involves the search for balanced proportionality between the partners—a «fair return,» in Piron's words. The point is, for the firms to find a fair distribution of goods and powers based on the goals sought and the resources committed by each. *Procedural justice* refers to the feeling that procedures have been fair. The point is for the participants to judge a decision-making process relative to a reference that is well known and considered legitimate. The factors that influence this include a feeling of participation in decision-making, an explanation of decisions, and clarity concerning expectations and the rules of the game, all of which influence whether the participants feel they have been treated fairly and equitably. Finally, *interactive justice* refers to individual interactions based on fairness in behavior, which makes it possible for a decision to be considered doable. Hence, respect and courtesy between allies proves to be important in fostering a positive atmosphere for interpersonal relations during the co-operation process.

Conclusion

By emphasizing the *«renewal paradox»* of non-innovative, project based construction firms, Ekstedt, Lundin and Wirdenius (1992) pointed out the importance of a «permanent» organizational context in providing a sustainable environment for innovative projects over time. In line with this thesis, this chapter illustrates how, over

30 years, the multiple and diversified innovative breakthroughs in the car ICE systems trajectory are linked with major changes in the internal organization of the studied firm in relation to its operating environment.

In the transformation process of the innovative design system of the firm, the «co-learning,» inter-firm cooperation model appears to be the final, promising but also problematic step in meeting the challenge of the intensive innovation context. The co-learning situation can be described in the following matrix. It describes a situation where the partners of the innovative cooperation are confronted by both important economic stakes, in terms of market shares and investment, *and* great uncertainties with regard to the possible results. Such a situation differs from that of a co-research partnership, where the stakes are less important, and from a co-development alliance, where the focus on the planned target is a key resource for inter-firm coordination.

Uncertainties and risks Economic stakes (market & costs)	Low	High
Low		Research partnerships
High	Co-development	Co-learning

Table 3: Different cooperation situations in innovative design processes
Source: Midler 2000

We pointed out in our last section some of the characteristics of and conditions for efficient co-learning management; these include multi-projects, multi-horizons management, immaterial results, loosely framed relations and commitments, and shared feeling of equity among the participants. Such characteristics clearly cannot be described by traditional project management models. The opportunities for research into innovative project management in the new millennium are still great.

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Bibliography

Abernathy and Utterback. 1978. Patterns of Industrial Innovation. Technology Review, 80 : pp 40–47.

Benghozi, P.J., Charue Duboc, F., Midler, C. 2000. *Innovation Based Competition & Design Systems Dynamics*. Paris: L'Harmattan.

Ben Mammoud-Jouini S., and Midler, C. 1999. «Compétition par l'innovation et dynamique de la conception dans les entreprises françaises. Réflexions à partir de la confrontation de trois secteurs.» *Entreprise et Histoire* no. 23:pp36–62.

Brown, S.L. and Eisenhardt, K.M. 1997. «The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations.» *Administrative Science Quarterly*, vol. 42, no. 1, March.

Chapel, V. 1996. «La croissance par l'innovation : de la dynamique d'apprentissage à la révélation d'un modèle industriel. Le cas Tefal.» Thèse de doctorat spécialité Ingénierie et Gestion Thesis, École Nationale Supérieure des Mines de Paris, Paris.

Clark, K. B., Fujimoto, T. 1991. *Product development performance. Strategy, organization and management in the world auto industry*. Cambridge, Mass.: Havard Business School Press.

Ekstedt, E. Lundin, R.A., Wirdenius, H. 1992. "Conceptions and renewal in construction companies", *European Management Journal*, 10: 202–9.

Ekstedt, E. Lundin, R.A., Söderholm, A., Wirdenius, H. 1999. *Neo-Industrial Organising*, Routledge, New York.

Garel, G., Kesseler, A. and Midler, C. 1997. «Le co-développement, définitions, enjeux et problèmes.» *Educations Permanente* .

Garel, G. and Midler, C. 1998. «An analysis of co-development performance in automotive development processes: a case study testing a win-win hypothesis.» Pp. p. 403 in *5th International Product Development Management Conference*,. Como Italy.

Hatchuel, A. and Weil, B. 1999. «Design Oriented organisations. Towards a unified theory of design activities.» in *6th New Product Development Conference*. Cambridge U.K.

Kesseler, A. 1998. «*The Creative Supplier : a New Model for Strategy, Innovation, and Customer Relationships in Concurrent Design and Engineering Processes : the Case of the Automotive Industry*.» thèse de Doctorat, spéc. Gestion Thesis, Ecole Polytechnique, Paris.

Lamming, R. 1993. *Beyond Partnership : Strategies for Innovation and Lean Supply*. London: Prentice-Hall.

Lemasson, P. and Weil, B. 1999. «Nature de l'innovation et pilotage de la recherche industrielle.» *Cahiers de recherche du CGS, Ecole des Mines de Paris*

Lenfle, S. 2001. «Compétition par l'innovation et organisation de la conception dans les industries amont. Le cas d'Usinor.» , Gestion, Université de Marne la Vallée, Janvier 2001.

Lenfle, S. and Midler, C. 2000. «Innovation-based competition and the dynamics of design in upstream suppliers.» *International Vehicule Design Journal* .

Lenfle, S. and Midler, C. 2002. "Innovation in automotive telematics services: characteristics of the field and management principles", International Product Development Conference, Sophia Antipolis, June 2002.

Lundin, R.A. and Midler, C. 1998. *Projects as Arenas for Renewal and Learning Processes*. Norwell, Mass, USA.: Kluwer Academic Publishers.

Midler, C. 1993. *L'auto qui n'existait pas; management des projets et transformation de l'entreprise*. Paris: Dunod.

Midler, C. 2000. *Les partenariats interentreprises en conception*. rapport de recherche à l'ANRT., Paris.

Midler, C. 2002. «Project Management for Intensive, Innovation-based Strategies.» in *The Frontiers of Project Management Research*, D.P. Slevin, D.I. Cleland and J.K. Pinto, eds. PMI, Newtown Square, Pennsylvania, pp. 135–150.

Piron, Ph. 2000. «Managing Joint development in Transnational Alliances the Case of European tactical Missile industry.» pp. 161–193 in *Innovation Based Competition and Design Systems Dynamics,* edited by C. Benghozi, Midler. Paris: L'Harmattan.

Piron, Ph. 2001. *L'alliance en convergence. Développer conjointement dans l'industrie européene des missiles tactiques*. Ph.D. Thesis, Ecole Polytechnique, Paris.

Weil, B. 1999. *Conception collective, coordination et savoirs. Les rationalisations de la conception automobile.* Phd Thesis, École Nationale Supérieure des Mines de Paris, Paris.

Appendix 1: Historical Overview of Car radio Product

	1950	**1960**	**1970**	**1980**	**1990**	**2000** *prognosis*
User perceptible product value	Simple radio	Radio	Radio with integrated compact cassette Stereo Digital (LCD) display	Radio with integrated with CD player Radio with interface for analogue car phone Remote control on steering column External display on dashboard	RDS (Radio data system) & TMC (Traffic message channel) Radio connected CD changer Digital Sound Processor Radio with digital car phone	integrated within car PC (car phone, navigation system, speech recognition, email, fax, phone, TV, CD ROM) Digital Audio Broadcasting
Additional feature regarding information transfer	Receiving music and information		Play recorded information	Receive simultaneously music, information and simple data	Receive specific, filtered traffic information	Interactivity ; Multimedia ; Customization of products
Technological progress	**Tubes** used since the beginning of car radios	**Transistors**	Additional module: Tape Deck	**Integrated circuits** Additional module: CD Laser technology; digital data compression; robust micro mechanics	Speed and capacity of microprocessors Object oriented programming Communication busses Flat screen displays	Speed and capacity of microprocessors
Frequency ranges	Short Wave (SW); Medium Wave (MW) ; Long wave (LW)	SW, MW, LW, Frequency Modulation (FM or UKW)	SW, MW, LW, FM	SW, MW, LW, FM + subcarrier	SW, MW, LW, FM + subcarrier	SW, MW, LW, FM + subcarrier and DAB transmission bands
Selection of radio stations	Manually with rotary button (capacitor technology)	Manually and mechanical pre-select buttons	Manually and mechanical pre-select buttons	Electronic search of stations (Phase Locked Loop)	Fully electronic search (autostore, alternative frequencies, program type recognition, ...)	Electronic with various features depending on choice of customer
Product destination region	France	Europe	Europe	Europe	World	World

Appendix2: Product Evolution from Auto Radio to Information-Communication-Entertainment Systems

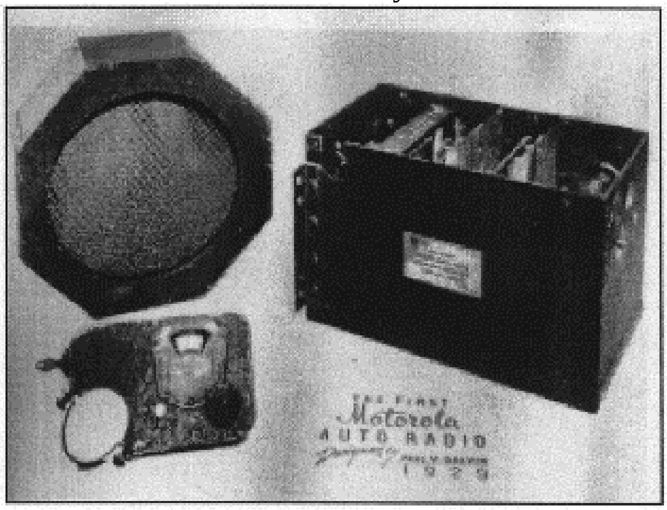

Figure1: First car radio 1928 (Motorola)
Source: Kesseler, p. 101.

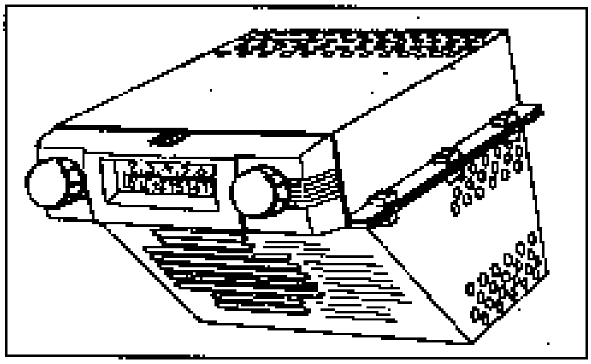

Fig 2: Circa car radio, 1955,
Source: Kesseler 1998, p. 103

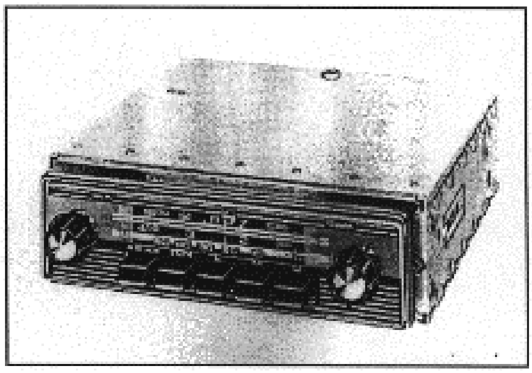

Fig 3: All transistor car radio, 1967, Philips
Source: Kesseler 1998, p. 104.

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Fig 4 : PCS information-communication-entertainment system, 1995.
Source: Kesseler 1998, p. 108

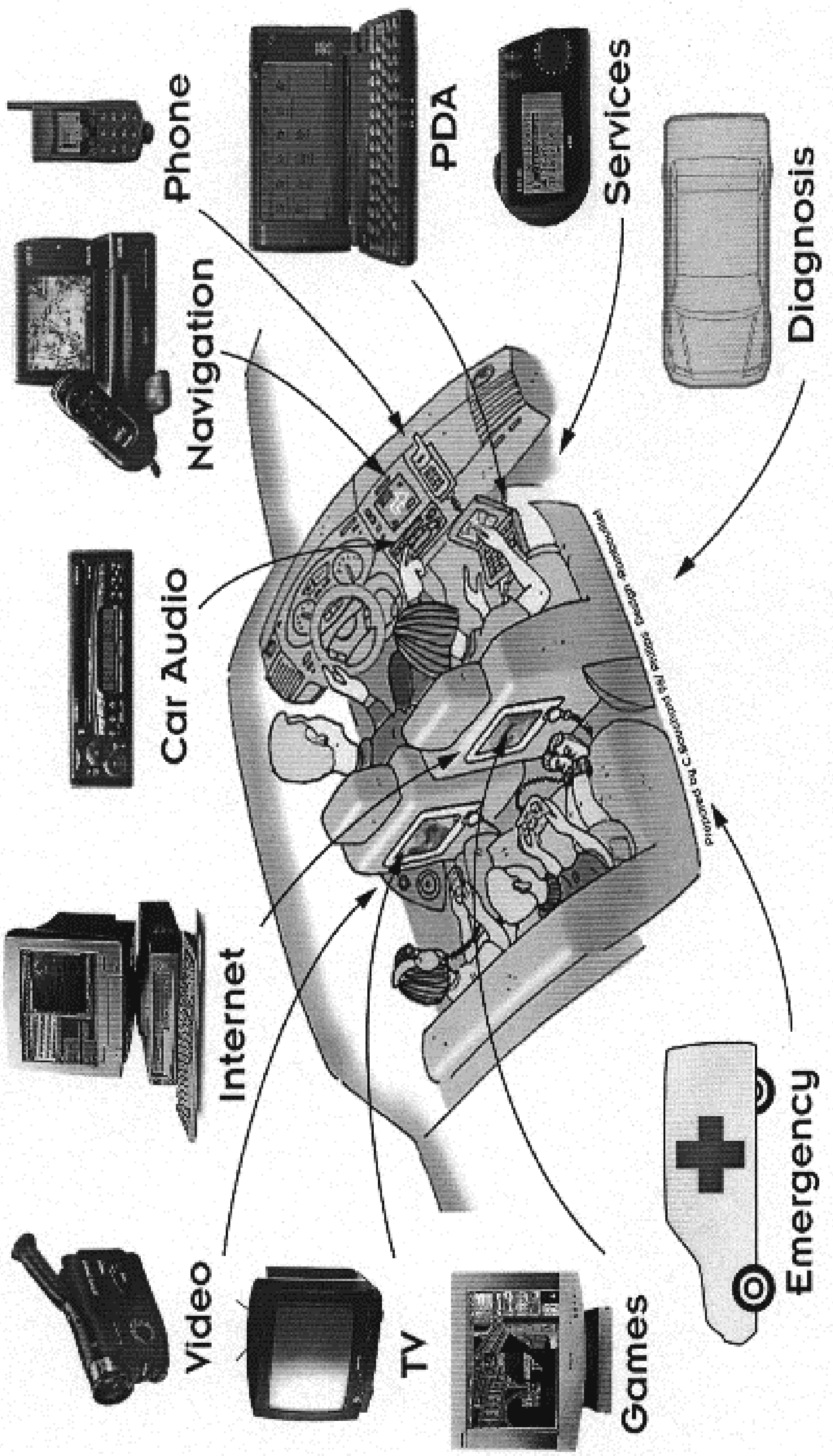

Figure 5: Future services provided in ICE systems.

Appendix 3: Transition from Hardware to Software