ONZIEME RENCONTRE INTERNATIONALE DU GERPISA
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Les acteurs de l'entreprise à la recherche de nouveaux compromis ?
Construire le schéma d'analyse du GERPISA

Company Actors on the Look Out for New Compromises
Developing GERPISA's New Analytical Schema

11-13 Juin 2003 (Ministère de la Recherche, Paris, France)

DESIGNING FOR SUSTAINABILITY: TOMORROWS' CAR ENCOMPASSING ENVIRONMENTAL PARADIGM

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The automotive sector is going through a worldwide re-structuring process, started by the 70's oil shocks and by the Japanese boom, which was strongly increased by the emergence of the environmental paradigm. This paradigm represents a technical, economical and social changes that settled the basis for a Sustainable Development commitment among the auto-industry stakeholders'. Sustainable Development is a new option for development that outlines the eco-development on the social and economic growth models, incorporating "environmental suitable strategies for fostering more equitable socioeconomic developement."(Sachs, 1993, quoted in Barreto M.L. 2000).

For auto-industry, for instance, this commitment concerns not only car designers, car manufacturers and theirs suppliers, for technical and industrial aspects, but also governmental agencies and non-governmental organizations, for the political and legal aspects involved. It involves the redesign of the actors' network settled on new compromises driven towards an environmentally production and consumption systems.

In this sense the strategies adopted by North American and European companies, for keeping and sustaining their share of the market, were focused on technical and organizational innovations, especially concerning the reduction of the time lag between conception and commercialization of new models as well as the adoption of environmental driven concept-cars solutions. A wider range of options among standard cars and a great effort on improving the quality and reducing environmental impacts were the main goals. To produce vehicles which respect both people and the planet has been a constantly growing commitment from the nineties.

These objectives were reached by integrating the environmental concerns into research, design, and production levels, in a multidisciplinary approach assisted by simultaneous engineering methods. By doing so, the distance between research and production has been drastically reduced, avoiding back and forth efforts that usually take a lot of time and money from the governments, enterprises and society in general. In this sense there are many long lasting international research projects aiming at evaluating and enhancing technological and organizational innovation environmentally driven such as the ULASB (ultra

light automobile steel body), the PNGV (partnership for a new generation of vehicles), the EUROCAR (European car program for European Union).

In this context for the auto industry design and innovation strategy task overlap, the core idea claimed by simultaneous engineering, is the main management method adopted, and its implementation is done through early release of partial design information within the team in order to allow downstream preliminary environmental considerations right from the very beginning. For materials producers, for instance, auto-parts suppliers, and automobile manufacturers the key factor for succeeding in the next century seems to be the continuos and larger inter firms cooperation keeping themselves side by side anticipating together environmental requirements and fostering new technological and organizational advances.

This paper discusses the issue of auto industry encompassing environmental paradigm by means of an environmentally driven design to support Sustainable Development commitment. This contribution is based on a new subject of research, that has been recently initiate by the authors, towards the evolution of design activities responding to environmental regulation. We aim at analyzing recent empirical studies on automotive industry environmental strategies and practices, as well as developing a case study on the configuration of car recycling as a new branch of car industry. In this sense we should adopt a multidisciplinary approach that deals with economy and production engineering, industrial ecology as well as social and environmental sciences. The paper is divided into five main titles as follow: Introduction; The Sustainable Development Concept; The Automobile Life Cycle Assessment; Towards Cars Eco-design; Open questions for auto industry on Eco-design. The main objective of the paper is to highlight the environmental challenge in the new forms of design organization, the so called Eco-design, in auto industry for the propose of the next GERPISA Research Program discussion.

SUSTAINABLE DEVELOPMENT CONCEPT

What the ongoing debate on Sustainable Development proposes is forcing a public opinion commitment that will lead to social pressures for codes of behavior that are more restrictive for certain economic activities. Among these activities, materials production, and car manufactures are especially addressed vis a vis natural resources depletion and greenhouse effect.

The discussions about the concept of Sustainable Development go back to the 1970's, during the United Nations meeting. The 1972 Stockholm Declaration and the 1974 Cocoyoc Declaration reasserted the concept and the proposals of eco-development. However it was in 1980, in a document entitled "World Conservation Strategy" prepared by the International Union for the Conservation of Nature, that the term "Sustainable Development" was coined. The concept was closely followed by alternative strategies of action for its implementation. A series of workshops were held and reports were produced by international organizations, as a way of giving substance to the term and establishing principles. Among the most important ones is the United Nations Environment Program (UNEP) which supported the document "World Conservation Strategy". Finally the World Commission on Environment and Development (WCED) took the Brundtland Report (1987) definition for the Sustainable Development as being a development that satisfies the needs of the present without jeopardizing the abilities of future generations to satisfy their needs (Barreto M. L. et al 2000). To put it in a few words this concept is a long run approach for development models based on the binomial development /environment involving not only the economic growth but also the social and ecological dimensions.

Auto industry as a major materials consumer and with its important environmental contentious plays a central hole at the Sustainable Development strategies deployment. The concept was forced into the center of the competitive strategies debate by a recycling imperative that, according to Bellmann and Kahre (1999 p.721), has become integral to the process of conceiving, designing, building, and ultimately dismantling and disposing of cars and their component elements. Even if the concept is demanding as a strategy the car manufactures have already put it into a special place for the renewal of their industrial organization as well as of the automobile itself. From Renault's point of view for instance: "All the major global organizations including OECD, the UM and UNESCO, have adopted the concept, modifying it gradually over the years. Academic and researchers have also contributed to broadening thinking about issues and resources, while NGOs and community organizations have given their input. At he same time, Sustainable Development regulations, charters and standards have been developed. What began as an intellectually based "protest" movement has gradually became a development strategy for many transnational companies". (R&D 26, Oct. 2002. p.23)

Actually even if car companies are trying to address Sustainable Development principles in their future plans for encompassing environmental paradigm they recognize that the subject has many open questions that must be answered for the concept to be ready to integrate the design activities in a regular way. The dialogue is just beginning among the main participants of the large circle of car-industry stakeholders. The debate has to focus themes such as: corporate strategies, R&D and innovation policies, technical parameters for new and recyclable materials, and indicators of sustainability for materials processing, manufacturing and recycling. This is surely not an easy task for two reasons: the complexity of the issues that have to be addressed, and the large number of actors that must participate at this debate. The Renault, for instance, in a "Dossier Sustainable Development" *(R&D, October 2002) identified six different group profile that are supposed to be affect or to participate at this task force:

- ✓ Customers; which must have their expectations satisfied concerning design, price, performance, comfort, reliability and mobility, when a new vehicle is purchased, whether they live in industrialized countries or emerging ones.
- ✓ Shareholders; investors and associates that are more and more oriented to social, ethics and environmental concerns.
- ✓ *Employees;* in addition to workplace health and safety, car companies have to ensure that its employees' skill and knowledge can evolve to keep them employable even in environmental oriented car production systems.
- ✓ *Suppliers;* which are at the highest level of compromise for Sustainable Development proposes. In fact they are part of the car manufactures effort on designing and producing greener cars.
- ✓ *Production facility neighborhood;* it means that the company as a whole (plants, research centers and so on) must keep in harmony with their surroundings dialoguing with their neighbors.
- ✓ *Society;* it includes public and private institutional actors, among them: international authorities, governments and local authorities, universities and research centers, environmental organizations; NGOs, etc... which must have a permanent talk on the automobile industry impact on its environment.

In addition to all that social requirements Sustainable Development also means to keep economic sustainability of the auto-industry in terms of growth, profitability, competitiveness (quality, costs and delivery) at both local and global level. That is to say that environmental sustainability must also be achieved without jeopardizing the capacity of the auto industry of sustaining its competitiveness standards. A useful framework to provide the best results for this proposes is the LCA (Life Cycle Assessment) approach. In the nineties many case studies have been presented by international literature on automobile industry, such as Graedal (1998, p.1) that defines : "Life Cycle Assessments are an operational tool that serve a broader approach to the interactions of society and the environment termed industrial ecology. ... and its related topics : technological change, risk assessment, economic and legal implications, corporate structure, governmental interests."

LCA is also crucial for the Sustainable Development implementation by means of new forms of industrial designing and organization such as DFE (Design for the Environment), DFR (Design for Recycling), DFA (Design for Assembly and Disassembly), that have been adopted by the auto industry in response to the environmental challenges since the end of the last century.

THE AUTOMOBILE LIFE CYCLE ASSESSMENT

In the last twenty years the automobile industry established a new concept of production and innovation management that has promoted systematic and continuous advances in technological and organizational evolution. As a result the innovation process is getting more and more integrated enhancing a synergic view of product and process design, R&D, and manufacturing. In other words, the designing activity was enlarged to cope with innovation requirements, including the environmental one, from product and process research as well as at the industrial phase.

Moreover technological and organizational change is now part of the same process of global and continuous innovation supported by flexible new car projects made in flexible plants. In this scenario partnership is a key word. Different knowledge is shared by the automobile designers and a multidisciplinary know how has being created as a result of team work in "plateau" at the development of projects for new and innovative cars. From now on they do all that in partnership networks including materials suppliers, auto parts producers, electronic systems dealers, and, together, they have to rethink globally the conception of new cars balancing technical performance and environmental impacts, from the birth to the dead of the new vehicle. In other words, they are supposed to do life cycle assessment of the product during the project development. For instances they have to go from the assembling up to the disassembling specifications to enhance the recyclability of the automobile as a whole. And they have to do this as fast and as "innovatively" as possible to be competitive for one more century.

This means that companies are being challenged to achieve an integrated environment - what they call "plateau projet" in France - to develop their products in order to compress the design cycle and to improve project effectiveness. So the costs of the designing phase seem to be increased by R&D activities as well as investments on industrial plants. Actually designing activities were enlarged including, in a broader view, from the first marketing idea till the end of car's life, passing by R&D, prototypes; vehicle engineering, up to final assembling, "disassembling" and recycling. Furthermore they have to pass through all those phases together with their partners and always keeping the final client in mind.

So the automakers are nowadays redefining their product according to the consumers' expectations reaching to improve the engine performance as well as to rend the new models more comfortable, safer, easier to drive, and environmentally friendly. To meet these needs the industrial project of a new model has to be "alive" to incorporate the continuous advances that can provide it with new functions. And they do this by means of simultaneous engineering methods now widely spread throughout the company, as a philosophy of work organization to keep their competitiveness by means of continuous innovation strategy.

LCA is an analytical tool for evaluating the environmental impacts of a product by means of monitoring its environmental loading "from cradle to grave". It has been largely utilized in auto industry case studies, to analyze, for instance, the various recycling options to achieve a higher recovery rate for cars in the future. Recycling itself is an option to reduce cars environmental pressures but not always the best one. It depends on how the materials and on the recycling technologies associated. But anyway it is a lively and extremely important debate (and extremely important) to the car industry environmental strategy.

Quoting Shimokawa, Jürgens and Fujimoto (1997 pp-7/8) on that propose: "*However competitiveness is not the only criterion for evaluating and selection of assembly systems. (...) Environmental friendliness has become another important criterion in recent years. Although final assembly is a relatively "clean" process as far as air and water pollution is concerned, it may play a pivotal role with regard to the recycling of motor vehicles. In other words, how to incorporate 'disassemblability' to product designs, as well as how to design disassembly processes themselves could be a critical issue in the coming decades."*

This strategy also enables the design of "green cars" according to the most restrict regulation regarding emissions control as well as final disposal and recycling. The "Directive of the European Parliament and of the Council of European Union on End-of-life Vehicles" adopted by European Union members is the state of art of a negotiation process, between interested parties and public authorities, that lasts already a decade. Since the Act of Political Union signed in Maastrich in 1992 institutions and regulatory methods are changing in environmental rule making within European Union. The firms are getting more and more involved in the regulatory process and the European automakers are not only establishing their own environmental policies but also acting as responsible for the implementation of a program that depends on suppliers and partners as well.

The automobile companies, for instance, are expected to set up technical and economical solutions for end-of-life vehicles. In short they have to conceive a "disassembly" line, back to the auto-parts and materials producers. In short, they have to consider the automobile life-cycle production and use from the materials selection up to the final assembly techniques as well as the auto-parts, components, and sub-assembled systems provided by different suppliers.

Regarding the recycling regulations for example, the French automakers were pioneers in Europe in promoting voluntary agreements between all firms involved and the government. A so-called "l'Accord Cadre" was signed in 1993. This agreement set up goals such as: at 2002 all vehicles produced should be 95 % recyclable. Aiming at this target the French Companies: Peugeot, Citroën and Renault are now working together on assembling and "disassembling" technical specifications and materials identifications reaching separation for recycling. They have also to face the challenge of designing new models for recycling integrating carwaste criteria into the design process. The rules established by European Commission, as the European Directive on End of Life Vehicles in Oct. 2000, are an example of the wide dissemination of the principles of Sustainable Development concept in Europe. It

means not only recycling criteria, but also that a large range of environmental requirements have to be integrated into new car projects.

Nevertheless the LCA as a tool for the creation and development of sustainable products and plants was first proposed in 1991 by American Society of Environment Toxicology and Chemistry that defines the process as follows: *"The life-cycle assessment is an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and material usage and environmental releases, to assess the impact of those energy and material uses and releases on the environment, and to evaluate and implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation, and distribution; use/re-use/maintenance; recycling; and final disposal."(* Graedel, 1998, p.18).

According to Graedel LCA involves five stages of any typical complex manufacture product:

- ✓ Stage 1: producing of materials and components
- ✓ Stage 2: manufacturing operations
- ✓ Stage 3: product delivery
- ✓ Stage 4: purchase and customer use
- ✓ Stage 5: products end of life, recycling or final disposal.

For the automobile we can adapt this schedule as follows :

- ✓ Raw Materials Extraction (concentration, separation and refining)
- ✓ Chemical and Metallurgical Materials Processing (metals; plastics, composites, glass etc)
- ✓ Auto parts manufacturing , (mechanical systems and electric and electronic devices)
- ✓ Car manufacturing (final assembly line)
- ✓ Sales and Maintenance
- ✓ Auto parts and ELV– end of life vehicles- Recycling
- ✓ Recycled materials go back to materials processing
- ✓ Non Recycled ones go to final disposal.

Under Sustainable Development conditions, the material flows system should be compressed at the re-processing materials phase to increase secondary materials production instead of the primary ones.

TOWARDS CAR ECO-DESIGN

In a search for flexibility, at the production level as well as in redefining the concept of cars, as friendly as possible, the automakers are looking forward to extending its market that was restricted to only 20 percent of the planet by the end of the 20th century. To get there, without more harmful effects to the environment, they have to improve automobiles fuel efficiency as well as to reduce their CO_2 emissions and their final costs. And the continuous product and organizational innovation are surely the best strategy to balance these goals in order to conceive eco-cars or green cars. So the main trends to assure this balance is to rethink the way the cars are designed incorporating environmental parameters since the very beginning.

The process of diffusion of eco-design for industrial products and its importance for the auto industry was very well stated by Schiesser (in Vigneron et Patingre 2001 p.63) "*L'eco-conception est une démarche volontaire d'intégration de l'environnement dans la conception des produits. (...) l''éco-conception permet également d'être en phase avec les attentes citoyennes face aux problèmes globaux et locaux et dans certains cas d'anticiper la réglementation qui peut en découler. Trois secteurs sont particulièrement concernés : l'emballages, l'automobile et les produits électriques et électroniques. l'application de Directives Européennes permet d'y développer les approches cycle de vie.*"

On this propose, for instance, the Renault's Head of Research into Environmental Conservation Coordination Committee, Claude Delame declared: "*The future of the automobile depends on the capacity of car makers to continue their efforts to reduce the environmental impact of production, running, and of course, disposal of vehicles."* In this sense, the future efforts on R&D at Renault, besides the short term ones such as the development of more efficient catalytic converters and particulate filters, are running for low or free emissions vehicles by using:

- ✓ LGP (liquid petrol gas)
- ✓ Natural gas
- ✓ Electric vehicles
- ✓ Hybrid vehicles (combining electric and internal combustion engines)
- ✓ Fuel Cells (hydrogen that emits nothing but water vapor)

Furthermore the research efforts at production level go from non-polluting products and processes to organizing recovery and recycling for automotive materials as well as recycling loops for fluids. As Delame finalized *"Such loops will be increasingly built in from the design stage on: 'dismantling' will be facilitated, and the materials used (especially plastics) will be fewer, clearly identified and easier to recycle".* At Renault they are also focusing on the environmental protection by rethinking urban mobility as the Transport Policy Delegate, Daniel Angello had declared: "*Renault is now working as a 'mobility engineer' on creating vehicles and services that are adapted to the urban environment and on inter-operability between different modes of transport. Our research is beginning to focus on the development of intermodality*[1].

[1] This and the other aforementioned testimonies can be found at Renault's review R&D *Les futurs de l'automobile* 1998, 2020, 2040, a especial issue dedicated to the Renault's 100 Years.

The New Clio results are one of the best evidence of Renault's global innovation strategy towards environmental friendliness. This strategy, coordinated by the designing activity, has been promoting an integration of R&D between automakers and suppliers and also is seeking for new forms of flexibility for industrial innovation once for all. And even more than that I can say that this project is still alive. I mean that it is still being improved in order to incorporate new advances in industrial process, engine systems and materials to meet new environmental requirements as well as to make it more performance and cost effective. The New Clio -launched in Oct. 1998- was designed to be 95% recyclable, anticipating the European Directive on End of Life Vehicles standards, established in October 2000.

THE NEW CLIO ENVIRONMENTAL INDICATORS

Indicators	**Results**
Reduction of welding operations	-20% *
Reduction of the steps for the engine check in	-37% *
Reduction of fuel consumption	-15% *
Reduction of CO_2 emissions	-12%*
Recyclability rate	95%

Source: *Renault Media Tech Review Special Clio, 1998.*

OBS: * Compared to the former Clio version

The New Clio was launched simultaneously in three plants in Europe: Valladolid in Spain, Novo Mesto in ex-Yugoslav, and Flins in France, in October 1998 and one year late in Airton Senna plant in São José dos Pinhais, near Curitiba, in Brazil. It comes in 7 versions concerning the engine specifications and the fuel systems adopted: four gas versions (1.0 - only for Brazil- 1.2; 1.4; e 1.6) 8 V.; two diesel versions (1.6 16 V and a turbo-diesel direct injection); plus one electric version for urban uses, inspired on the concept car NEXT. And the year of 2000, Renault began to produce a new 1.0 16 V for Brazilian market, which associates a 1.6 regular engine performance to a lower gas consumption.

These results were obtained by means of a new style of project management and organization the so called by Renault "plateau project" where all the groups in charge of each automobile parts, systems, and devices, inside and outside the company, worked together at the conception, design, prototyping and assembly line.

OPEN QUESTIONS FOR AUTO-INDUSTRY ON ECO-DESIGN

The designing for global innovation seeking for sustainability was the main strategy adopted by world car companies regarding all these requirements integrating new criteria such as recycling and low emissions systems to cope with the restrict environmental regulations. Although different factors affect the diffusion of innovations concerning technological, economic or institutional aspects involved, the best trajectory seems to be work in simultaneous parternship for R&D, designing, and engineering activities up to the industrial level. Working in network partners share risks and profits and also get more innovative solutions to reach the sustainability of the automobile.

This is surely a great opportunity for the less developed countries' automotive plants to get into the designing activities, which up to now concerned only the headquarters bureau employees. But that is also a means of get from all partners and stakeholders their contribution to the sustainability of car industry and of the automobile itself. It also signifies that it is time for company actors to rethink and reestablish their compromises on Sustainable Development basis.

Lastly for GERPISA proposes its maybe a factor of convergence to be taken into account into the new analytical schema design. In our opinion auto industry is being forced to share a common productive paradigm concerning environmental issues. For instances, it has to address zero emission cars and plants, enhance cars recyclability, reach and maintain ISO 14000 Standards – for car manufactures and suppliers – to implement Sustainable Development models of production, sales, maintenance and recycling-. In short to look for a flexible and competitive organization that enables to conceive green-cars, made in green-plants by green technologies. That means to speed technological and innovation from the concept-cars to the design of standard versions. In this context the re-organization of design activities seems to be at the core of future strategies to add value to the automobile and its industry .

So we believe that environmental issues have some convergence that are supposed to have an important role on new compromises among company actors and government and non government organizations as well. This convergence goes mainly through :

- ✓ respecting and anticipating environmental legislation;
- ✓ avoiding toxicity in selecting automotive materials;
- ✓ establishing eco-criteria for materials selection;
- ✓ developing new and recyclable materials and processess
- ✓ looking for zero emissions cars and plants;
- ✓ increasing the recyclability rate of the automobile;
- ✓ developing sustainability parameters and indicators.

LCA and eco-design has a crucial role to play on this new scenario as a methodological framework and a new integrate approach for developing new productive models on new and sustainable basis for automotive industry on the twenty first century. Taking Graedel (1998) words: *It's fair to say that environmentally oriented actions will become the norm as the society of 21st century enfolds and if the tools* (LCA, DFE, DFR, etc. ...) *are used conscientiously the problematic interaction of society with its environment can be much mitigated.*

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