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PRODUCT SERVICE SYSTEMS IN THE AUTOMOTIVE INDUSTRY: AN ALTERNATIVE BUSINESS MODEL FOR A SUSTAINABLE SATISFACTION SYSTEM

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Abstract

The paper presents the intermediate results of an on-going research project called Vehicle Design Summit (VDS), run by an international Consortium of Universities coordinated by the MIT of Boston. The project aims at designing and prototyping an eco-efficient vehicle as well as defining an innovative and sustainable business model to introduce and diffuse it into the mobility sector. In this framework the paper explores the potential contribution that PSSs can have in moving beyond incremental technological improvements towards system innovation in the automotive industry. This is outlined presenting and discussing an alternative business model, characterized by: an approach to mobility as the scope of design; an innovative stakeholders network; a shift from selling products to selling results; a change in product ownership; and a consequent change in vehicle design.

Keywords: PSS, system innovation, design, sustainability, automotive industry, sustainable mobility.

1.0 Sustainable Mobility And The Vehicle Design Summit Consortium

Awareness of the environmental and social problems linked with mobility continues to grow. As a matter of fact it is a shared opinion that in the transition towards sustainable consumption and production patterns *mobility* is one of the priority area in which intervene to drastically reduce the use of resources per "unit of satisfaction" [1]-[2]. Several studies indicates four main unsustainable issues to focus on [4]-[5]: an high dependence on fossil resources and a consequent high level of environmental pollutant and damaging emissions; an increase in congestion levels; a lack in equity of access to mobility; and a still un-safety of transport, with high levels of injured people and fatalities. Mobility is deeply embedded in all aspects of life, and covers a wide range of activities (from people to goods transport), kinds of use (private and professional), and means of transport. In this sense it is obvious that mobility is characterized by a complex production and consumption chain involving different actors: private producers of vehicles, energy supplier, infrastructure

building companies, private and public transport service companies, insurance companies, political authorities and users. Given the complexity of the socio-technical system it is clear that there is a broad-spectrum of strategies that can be adopted to steer mobility towards more sustainable solutions, that generally speaking go from the increase of access to (environmentally sustainable) transportation means for low-income communities, to the drastic reduction of inefficient use of private vehicles in industrialized countries, to the promotion of more sustainable collective modes of transport, to the improvement of the sustainability performance of all modes of transport [3]-[4].

Within the complexity of the mobility domain and within the broad-range of the potential interventions, the focus of the work is on people transport, and specifically on proposing innovative and sustainable Product Service System (PSS) solutions based on the use of cars. A narrow field of action that however could potentially bring to significant environmental and social improvements, if considered that currently cars collectively represent the largest single source of global air pollution, accounting for 30% of industrialized country emissions and 17% of CO_2 emissions [5].

In this perspective the paper presents the intermediate results of an on-going research project denominated Vehicle Design Summit (VDS), run by an international Consortium of universities coordinated by the Massachusetts Institute of Technology (MIT) of Boston. The Consortium's goal is to design and realize a low environmental impact vehicle as well as the definition of the conditions for its introduction into the market through innovative and sustainable "mobility offers". The final aim is to influence and re-orient the whole automotive sector towards the adoption of radically more sustainable *offer* modalities and consequent *production* strategies. Each university has got a team of students working on a technical, strategic or organizational task of the project. The role of Politecnico di Milano team[1] is to design an innovative and eco-efficient business model, as well as a transition path to introduce and diffuse this model into the market. The assumed hypothesis is that incremental technological improvements in the automotive industry is a necessary but not sufficient condition to reach radical environmental impact reduction, and that (product service) system innovations are needed. For this reason a system design approach has been adopted, integrating products and services as well as the related socio-economic stakeholders and the user, with the aim of fulfilling specific demands of satisfaction. In other words the approach focuses on designing the system of actors and the related interactions and partnerships, in order to make eco-efficient the delivered "mobility offer".

In this framework the first part of the text analysis why (product-service) system design approach may be considered an opportunity to develop new business strategies, to compete and generate value and social quality, and at the same time decreasing the total amount of resources consumption and emitted pollutants. The argumentation will then focus on the sustainability problems associated with the automotive industry. Finally, the text will present and discuss the elaborated hypothesis for an alternative business model for a sustainable automotive industry.

2.0 Designing Sustainable Product Service Systems

By most design researchers a more significant ambit in which to act to promote radical changes for sustainable consumption, is the widening possibilities for innovation beyond the product, towards innovation

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of the system as an integrated mix of products and services that together lead to the satisfaction of a given demand for well-being [6]-[7]-[8]. In this sense PSS are shifting the centre of business from the design and sale of (physical) products alone to the offer of product and service systems that are together able to satisfy a particular demand. So when we talk about (product-service) system innovation, it is meant an innovation that involves all the different socio-economic stakeholders in this "satisfaction system". Furthermore, it is a shared opinion that these innovations could lead "to a system minimization of resources, as a consequence of innovative stakeholder interactions and related converging economic interests" [9]. Thus eco-efficient system innovation derives from a new convergence of interest between the different stakeholders: innovation not only at a product (or semi-finished) level, but above all as new forms of interaction/partnership between different stakeholders, belonging to a particular value chain, or "value constellation". In other terms, the research interest in this innovation model relies on the fact that it can raise system eco-efficiency through innovative stakeholders' interactions.

To understand in general terms why system innovation and innovative stakeholder interaction could be more eco-efficient compared to traditional product sales/design let's take as example the traditional offer of a washing machine. In this case the producer of the washing machine (but also of the detergent and the electricity) has an interest in reducing material and energy consumption during the production phase. On the contrary, he has no direct economic interest either in limiting consumption during use, or in reducing divestment impact and valorising the resulting waste. Sometimes the producer is even interested in selling products with a short life span, with the only aim of accelerating replacement. In other words it can be observed that the fragmentation of stakeholders in the various phases of a product's life cycle (in the traditional economic framework of industrialized countries), means that the eco-efficiency of the life cycle system usually does not coincide with the economic interests of the individual constituent stakeholders.

At this point proper questions are: which could be the incentives for companies to enhance the system eco-efficiency? In this sense innovative elements can be found in the stakeholder interactions and configuration that could be trans-phasal innovations (involving different phases of a product's life cycle), or trans-cyclic innovations (involving different product's life cycle in a satisfaction system)[10]. Without going into details, two helpful strategies are: a stakeholder integration (extension of control of a single actor in different life cycle phases different products and services within one satisfactory system); and an extension of the stakeholders interactions in time (more stakeholders extend their interaction within a given product life cycle or within PSS life cycles).

Thus eco-efficient system innovation derives from a new convergence of interest between the different stakeholders: innovation not only at a product (or semi-finished) level, but above all at configuration level, i.e. when setting up new forms of partnership/interaction between different stakeholders in a "satisfaction system". In this sense a (product service) system approach can "lead to a system minimisation of resources, as a consequence of innovative stakeholder's interactions and related converging economic interests". System innovation can be seen as a strategic innovation [11], a possible choice for companies to separate resource consumption from its traditional connection with profit and standard of living improvements; to find new profit centres, to compete and generate value and social quality while decreasing (directly or indirectly), total resource consumption. In other words, system innovation is potentially a win-win solution: winning for the producers/providers, the users and the environment.

The introduction of (product service) system innovation for eco-efficiency into design has led researchers to work on defining new skills of a more strategic nature, that aim at system eco-efficiency through the

stakeholders' strategic convergence of interests, and are coherent with the "satisfaction-based", "multi-life-cycle" perspective. In synthesis, the main characteristics of the system design for eco-efficiency approach are: a *satisfactory approach* (*demand-satisfaction design*); a *stakeholder interaction approach* (*stakeholder's configuration design*); and a *system eco-efficiency approach* (*ecoefficient-oriented design*). In this perspective design activity should focus on [10]:

1) developing environmentally sustainable products and services together;
2) promoting and facilitating new configurations (partnership/interaction) between different stakeholders, to find innovative solutions able to lead to a convergence of economic, social and environmental interests;
3) promoting and facilitating new sustainable locally-based and network-structured initiatives/enterprises;
4) facilitating a participatory design process among all the stakeholders.

Nevertheless it has to be underlined that not every (product service) system innovation is eco-efficient [10]-[11], and therefore it is of key importance to adopt appropriate methods and tools, when designing new systems (with the potentialities to be radically sustainable), that would steer it towards a sustainable solution. For this reason, in terms of the development of new systems it is expedient to operate and adopt appropriate criteria and guidelines. The first design methods and tools that have been recently developed as outcomes of some European projects of the 5th Framework Programme, are PROSECCO (Product & Service Co-Design process), HiCS (Highly Costumerized Solutions) [12], and MEPSS (Method for PSS development) [11].

3.0 Sustainability And The Traditional Business Model In The Automotive Industry

The automotive industry is characterized by a business model in which vehicle manufacturers represent the pivotal actor, directing both component suppliers and the distribution and retailing system [13]; and their primarily source of profits is the sale of new vehicles. Within this model, vehicle producers, in order to increase profit margins, have adopted a strategy of mass production, that brought to high volume output and

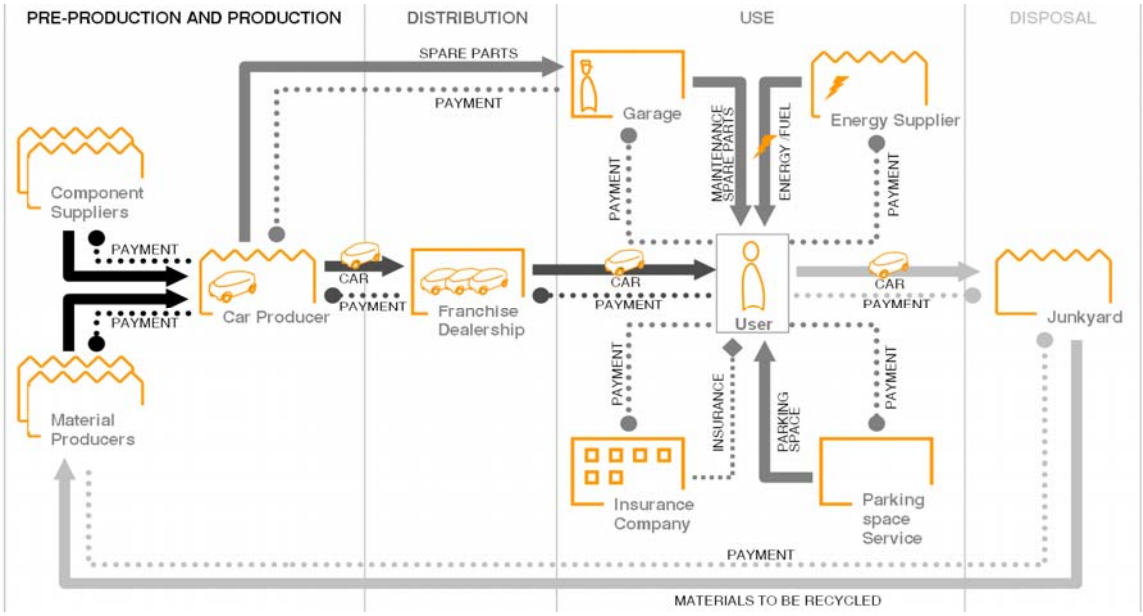

Fig. 1. Simplified stakeholders system map visualizing all the actors and the related interactions (in terms of material, informational and financial flows), of the traditional business model in the automotive system.

PSS IN THE AUTOMOTIVE INDUSTRY: AN ALTERNATIVE BUSINESS MODEL FOR A SUSTAINABLE SATISFACTION SYSTEM

high volume of sales to global market [14]. The main reason is that some of the production technologies necessary in the manufacture processes are high capital intensive, and therefore companies have to sell greater number of cars in order to recover the initial investments. In this sense there is an high break-even point that act as a barrier for the entry of new competitors into the market and moreover encourages the establishment of even larger global operation [15], and conservative design attitude. This is why is often less costly for a vehicle manufacturer to overproduce and oversupply newly produced cars than to cut back on manufacturing capacity [14]. In synthesis all these elements brought to a situation characterized by the presence of large centralized and conservative mass producers aimed at selling the higher amount of vehicles to global markets. From an economical point of view, return to capital are low, typically below 5% and often negative with periodic crisis [13]. The reason is that the overproduction lead companies to offer incentives in order to create increased demand, and therefore as result we have a continuous discounting of the price of new cars, and a consequent reducing in profit margins. What it has to be underlined is that vehicle producers earn their profits mainly from the cars sale and the spare parts sale, but they do not catch most of the earnings associated with the use of the vehicle. In fact, how illustrated in fig. 1, the automotive system of production and consumption is characterized by a variety of stakeholders, and the profit generated by cars in use go mainly to fuel companies, independent garages and insurance companies [16].

In the automotive production and consumption system, in terms of environmental sustainability, the main impact along the vehicle life cycle are [17]:

- in the use phase, cause of the several pollutants present in the emissions of the vast majority of cars (exhaust fumes from cars represent the biggest source of air pollution in half the world cities [18]);
- in the pre-production and production phases, cause of: high levels of energy, water and non-renewable materials (and the related emissions) used in the manufacturing processes; and cause of the use of some specific production processes like painting and metal finishing;
- in the distribution phase, cause of the logistic and distribution system required for global market sales;
- in the disposal phase, cause of the high waste flow at the end of cars' life (in the European Community end-of-life vehicles are responsible of between eight and nine millions tones of waste each year [19]).

In relation to these environmental impacts, it has to be underlined that there is a fragmentation of actors in the various phases of a product's life cycle (fig. 1), and this makes the eco-efficiency of the life cycle system not coincident with the economic interests of the individual stakeholders. To better understand this concept let's take in consideration the car producer. Of course it has the interest in reducing the amount of energy and material used in the production phase, with a convergence between economic interest and resources optimization. On the contrary, as it has been described before, the vehicle producer has got also the interest in selling the greater amount of vehicle (and therefore to accelerate its replacement), and a no direct interest in reducing consumption in use. In this sense the economic interest does not coincide with a resources minimization. In the same way fuel companies are economical interested in selling how much fuel they can, and garages have a direct interest in selling the higher quantity of spare parts. In other words, the biggest environmental problems do not appear within one given phase, when related to a single stakeholder (e.g. vehicle manufacturer). In terms of eco-efficiency, more problems arise in the so called "phase's transaction", during the sale or disposal of products (e.g. the sale of vehicles or the sale of fuel). Here can occur indifference towards reducing resources consumption; or even worse an interest to increase consumption of resources.

PSS IN THE AUTOMOTIVE INDUSTRY: AN ALTERNATIVE BUSINESS MODEL FOR A SUSTAINABLE SATISFACTION SYSTEM

In conclusion it is possible to say that the automotive sector is characterized by a stakeholders fragmentation along the life cycle phases (fig. 1), and the consequence is that the economic interest of each single actor does not coincide with an interest in optimize the resources use on a system level. For this reason vehicle producers are not directly interested in design and realize high efficient, long lasting, reusable and recyclable cars; and fuel companies are not directly interested in having in the market low-consumption vehicles.

4.0 Hypothesis Of Alternative Business Model For A Sustainable Satisfaction System

The definition of an alternative business model is based, as previously mentioned, on a system design approach, integrating products, services, the related socio-economic stakeholders and the user, in order to fulfill a given demand of satisfaction. The aim is to design the interactions and partnerships between the various actors in order to make eco-efficient the delivered offer of "mobility".

4.1 Characteristics Of The Alternative Business Model

The first characteristic of the alternative business model (fig. 2), is that the car is produced by small-scale and locally-based manufacturers. In this sense the idea is to take up the already elaborated micro-factory retailing (MFR) concept [13]-[20], and to use it as starting point for the business model development. As it has been argued [13]-[20], the MFR approach can potentially facilitate the adoption of eco-efficient PSSs via aspects such as the unification of the commerce and manufacturing function, and the proximity of manufacturing and servicing sites to users. But differently from the MFR concept, small manufacturers do not operate alone. In fact it has been imagined a partnership between them, an energy supplier and an insurance company. The generated partnership keeps the ownership of the vehicle and offers a service of "access to mobility" (e.g. car sharing). This service is supported by the local administration (which provides facilitations such as parking

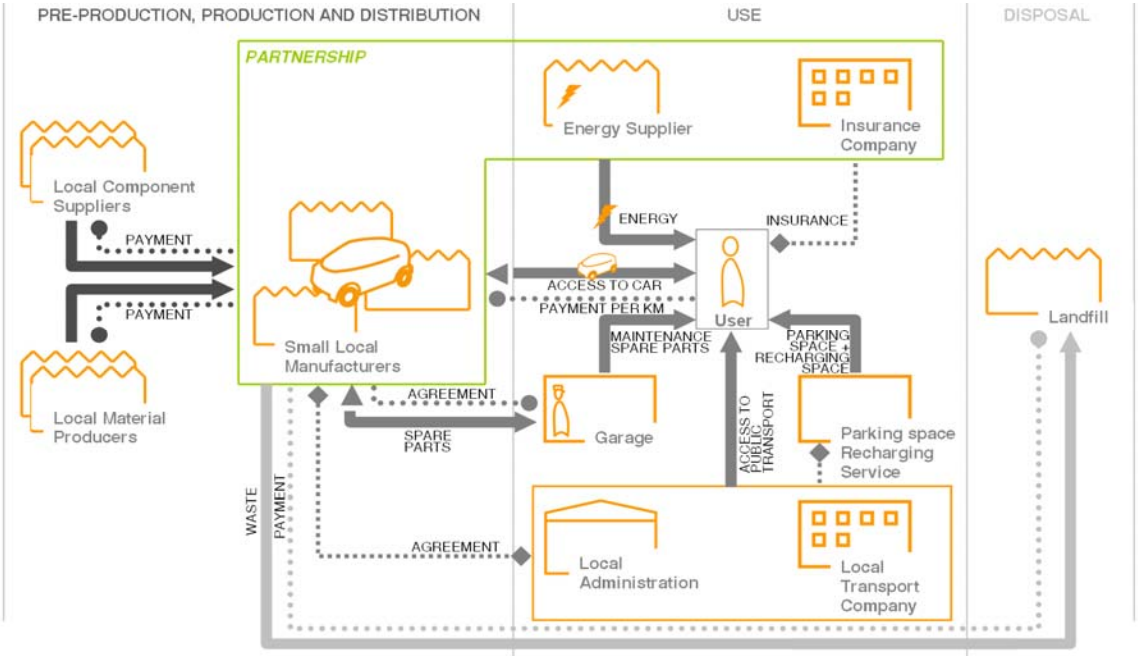

Fig. 2. Simplified stakeholders system map visualizing all the actors and the related interactions (in terms of material, informational and financial flows), of the alternative business model for a sustainable automotive industry.

spaces and vehicles' recharging spaces), and is in collaboration with the local public transport company (in order to facilitate inter-modality of transport). A series of garages displaced on the territory and in agreement with the partnership, will provide the needed maintenance. The payment of the service is per "unit of satisfaction", and so in this case per kilometers covered; it includes the use of the vehicle, the needed energy supply, the insurance, the maintenance, as well as free parking space and access to public transport. Moreover the partnership will deal with the vehicles' upgrading and take-back service.

Four main innovative characteristics can be identified:

- *an innovative stakeholders network,* including actors like energy supplier, insurance company, local administration and public transport company, which usually works autonomously within the supply chain; in this way the stakeholders' fragmentation along the life cycle phases, and the related indifference in system resources optimization (present in the traditional business model), are avoided.
- *a shift from selling products to selling results,* meaning that it is not the vehicle and the fuel that are sold, but what it is offered is a service of "access to mobility". Users do not pay for the vehicle, the fuel, the spare parts, etc, but they pay per unit of "satisfaction".
- *a change in product ownership,* in the sense that, differently from the traditional sale models, the partnership providing the PSS solution keeps the ownership of all the products that are part of the solutions (vehicle, fuel, etc.). As a consequence the relationship between the producer and the user does not end after the transaction (as in the traditional business model), but continues in time.
- *a change in product design,* in order to make profitable the PSS solution; in this sense the vehicle's requisites should be, besides consumption-efficient, even easily up-gradable, maintained, disassembled, reused and recycled.

4.2 The Eco-Efficiency Of The Business Model

As previously described, the alternative business model has been designed in order to make the economic interest of each single stakeholders coincident with the resources optimization on a system level. And this characteristic has been reached through the design of innovative interactions and relationships between the various stakeholders. Looking to the elaborated business model, the partnership has a direct economic interest in reducing the energy consumed in use by vehicles, in order to decrease costs and maximize profits; in fact, being the payment of the service "per km covered", less energy is used by the vehicle per km, minor will be the costs and consequently higher the profits. In this sense the energy supplier and the producer have an economic incentive in developing vehicles and energy systems based on renewable sources (sun, hydrogen, etc.), to save on the cars' energy recharging costs (paid by the partnership and no more by clients). Moreover, since the partnership remains the owner of the vehicle, it is economically interested in extending the product's life span, in order to postpone the disposal cost and the cost for the manufacturing of a new vehicle. For the same reason the partnership has an economic incentive in re-use or re-manufacture components to avoid landfill costs and new component production costs, and in extending material life, though recycling or energy recovery. Furthermore the partnership, through the agreement with the local administration and public transport company, is motivated in facilitating the integration between different transportation modes. In this way the local administration obtains a potential reduction of traffic congestion and emissions and an intensification in the public transport use; on the other hand the partnership gains facilitation like parking and recharging spaces. Finally it has to be underlined that the partnership is also motivated in avoiding accidents,

in order to preserve cars and have less insurance costs. In this sense they could be potentially interested in reducing the vehicle acceleration and in adopting intelligent system for example to narrow down the speed within set limits.

5.0 Directions For Future Research: Designing Transition Paths For Sustainable System Innovation Introduction And Diffusion

Before it has been underlined that design could play a key role in orienting and supporting the design process towards the definition of environmental sustainable solutions. Now the research challenge is to understand which could be the potential role of design in defining the proper conditions to foster the introduction and dissemination of sustainable (product service) system solutions.

In this sense DIS research unit is now working on the elaboration of a so called "evolutionary transition path": a strategy for the introduction and diffusion of sustainable system innovations starting form an university research context and through an "open-source" philosophy. A transition path that can be described as a strategic orientation and adaptation of the steps that, through a continuous iterative multi-stakeholder learning process, brings to: the *design of a sustainable solution (I)*, its *experimentation in a pilot project (II)*, its *implementation (III)* and its consequent *diffusion (IV)*.

References

[1] Suh, S., Materials and energy flows in industry and ecosystem netwoks : life cycle assessment, input-output analysis, material flow analysis, ecological network flow analysis, and their combinations for industrial ecology. Leiden, Netherlands: CML Leiden University, PhD Thesis, 2004.
[2] Weidema, B.P., A.M. Nielsen, K. Christiansen, G. Norris, P. Notten, S. Suh, and J. Madsen, Prioritisation within the integrated product policy. 2.-0 LCA Consultants for Danish EPA, Copenhagen, Denmark, 2005.
[3] EU COM551, Green paper. Towards a new culture of urban mobility, Brussels, 2007.
[4] Geerken, T., Sustainable consumption and production in the mobility domain, working paper, SCORE!, 2008.
[5] M. Carley and P. Spapens, Sharing the world – sustainable living and global equity in the 21st century, Earthscan, London, 1998.
[6] Goedkoop MJ, van Halen CJG, te Riele HRM, Rommens PJM, Product service systems – ecological and economic basics, The Hague, Den Bosch & Amersfoort: Pi!MC, Stoorm C.S. & PRé Consultants, 1999.
[7] Brezet, H. et al., The design of eco-efficent services. Methods, tools and review of the case study based "Designing eco-efficent Services" project, report by VROM, The Hauge, 2001.
[8] Manzini E., Vezzoli C., Strategic design for sustainability, in TSPD proceedings, Amsterdam, 2001.
[9] UNEP, Product-Service Systems and Sustainability. Opportunities for sustainable solutions. UNEP, Division of Technology Industry and Economics, Production and Consumption Branch, Paris, 2002.
[10] Vezzoli C., System design for sustainability. Theory, methods and tools for a sustainable "satisfaction-system" design, Maggioli editore, Rimini, 2007.
[11] Van Halen C., Vezzoli C., Wimmer R. (edit by), Methodology for Product Service System. How to develop clean, clever and competitive strategies in companies, Van Gorcum, Assen, 2005.
[12] Manzini E., Collina L., Evans S. (edit by), Solution oriented partnership, Cranfield University ed., Cranfield, 2004.
[13] Welles P., Alternative business model for a sustainable automotive industry, proceedings, Perspectives on Radical Changes to Sustainable Consumption and Production (SCP), SCORE! Network, Copenhagen, 2006.
[14] Williams, A. Product service-systems in the automotive industry: a case for micro-factory retailing, *Journal of cleaner production*, volume 14, issue 2, pp.172-184, 2006.
[15] Nieuwenhuis P. and P. Wells, The automotive industry and the environment, Woodhead Publishing Limited/CRC Press LLC, Cambridge England/Boca Raton, FL, USA, 2003.
[16] Wells P. and P. Nieuwenhuis, The automotive industry – a guide, CAIR, Cardiff, UK, 2001.
[17] Department of Trade and Industry (DTI) (UK), The environmental impacts of motor manufacturing and disposal of end-of-life vehicles – moving towards sustainability, Cleaner Vehicles Task Force Report, HMSO, London, 2000.
[18] SustainAbility & United Nations Environment Programme (UNEP), Driving sustainability – can the auto sector deliver sustainable mobility, Paris, France, 2001.

[19] Official Journal of the European Communities (OJEC), Directive 2000/53/EC of the European Parliament and of the Council on 18 September 2000 on end-of-life vehicles, Brussels, 2000.
[20] Nieuwenhuis P., An ecosystem approach to the transition to new business models, proceedings, Framework for Action for Sustainable Consumption and Production (SCP), (SCORE!) Network, Brussels, 2008.

PSS IN THE AUTOMOTIVE INDUSTRY: AN ALTERNATIVE BUSINESS MODEL FOR A SUSTAINABLE SATISFACTION SYSTEM