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ENHANCING SUPPLY CHAIN COLLABORATION IN AUTOMOTIVE INDUSTRY BY VALUE DRIVEN SIMULATION

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ABSTRACT
This paper presents a computer-based approach for conceptual design that aims to enhance collaborative supply chain development in the automotive sector when dealing with product-service development or radical innovations. The focus of the research has been to design a simulation approach that will enable designers and managers to simulate and evaluate the value of different design options for the different stakeholders involved in the development process and to have insights about the implications between business model innovation and the engineered aspects of the solutions early in the conceptual phase.
The approach is presented using a case study within the current project, after following a team responsible for the car cockpit. Four possible scenario have been simulated and evaluated using a commercial simulation software.
The main advantage of the proposed approach is to enhance the awareness among designers and managers of the value of different design options, and allow them to explore further how business and design aspects profoundly affect each other, in order to support early decision-making in the design process.

Keywords: value engineering, simulation driven design, product-service systems

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1 INTRODUCTION

Manufacturing companies have traditionally focused their design and development activities on realizing technical and engineering aspects of physical artefacts. The changed business climate due to increased competition on the global market have forced these companies to continuously innovate their product portfolios as well as exploring new type of business models (Tukker and Tischner, 2006). This has led to an increased attention of creating radical innovative product concepts as well as initiatives as Total Offers, Functional Products, Product-Service Systems and Integrated Product Service Engineering, hereafter named as PSS in this paper (Meier et al., 2010) (Baines et al., 2007) (Alonso-Rasgado et al., 2004).

The automotive industry is experiencing this changing context. Car manufacturers and their suppliers have in recent years explored new ways of providing customer value, including new types of business models (such as functional provision, car renting, car sharing, car pooling) (Katzev, 2003). The market has evolved rapidly, largely driven by the consumers' needs to make a more sustainable choice for their transportation habits as well as increased requests for well-being (Botsman and Rogers, 2010) besides the classic feature improvements. New actors are currently taking market shares that traditionally belonged to car manufacturers and dealers, such as car sharing platforms (Shaheen et al., 2009). Peer-to-peer car sharing represents a recent phenomenon in the arena (Hampshire and Gaites, 2011). Customers are spontaneously experimenting with new business models using the car as a platform, a process though which a person either rents a vehicle from someone else, or conversely, rents their own vehicle to someone else, usually by the hour or day, via a third-party operator that facilitates the exchange (Lewis and Simmons, 2012).

Some car manufacturers are reacting to this evolving situation, introducing new services in order to exploit the opportunities offered by the new market. Recent examples include the partnership between General Motors and a US based peer-to-peer car sharing platform. Car owners who subscribe to GM's OnStar system will be able to rent their vehicles out to other drivers. GM's OnStar system makes use of satellite-connected on-board services, but its capabilities have up till now been used mostly to call for assistance in case of emergency. Under this new partnership, the peer-to-peer sharers that subscribed to the platform can use the OnStar system to reserve a car and lock and unlock the door via a mobile app.

From the standpoint of a car Original Equipment Manufacturer (OEM) and its suppliers collaboratively working on the development of new models and technologies, it is extremely important to gain a better understanding of the consequences of their design decisions on the overall system (e.g. the customer journey), the value for the different stakeholders or a new function's impact on future scenarios.

In this context, the satisfaction of the design requirements does no longer assure that the design will create an "uncontested customer value", and thus there is a need to integrate the design requirements with more qualitative measures that link the product features to the stakeholders' needs and expectations, and increase the ability of the design team to make design decisions taking into consideration future trends as well as new business models.

The main objective of this paper is to provide an understanding of the challenges that a design team faces when dealing with the consideration of the value contribution of different design alternatives in the conceptual phases. Special emphasis has been given to the consideration of the impacts on customer and the supply chain value provided by a design option in relation to new business models, and how technical design and business model design mutually affect each other.

The paper also describes a conceptual approach aiming at overcoming the underlined challenges at the preliminary design stages. The approach is described in terms of key elements, actors involved and activities performed.

2 RESEARCH APPROACH

The work reported in this paper is part of a research project within the automotive industry. A Swedish car manufacturer works along with 30 companies works in a supply chain structure. The aim of the project is to explore new opportunities for the automotive industry for 2021, both in terms of hardware and new business models; hence the PSS context is relevant.

The authors have observed and participated in a total of nine design workshops within the project in an 18 month timespan, being responsible directly for two workshops on the topic of value creation.

During these workshops and follow-up meetings the authors have collected data by informal dialogues, which contributed to frame the core problem statement and subsequently the approach presented in this paper.
A case study approach (Yin, 2008) has been chosen to empirically identify the challenges when dealing with value assessment in conceptual design and the consideration of the design's implications on future scenarios. A design team responsible for the design of the cockpit has been followed closely during a four-month period, and the case reported in the paper is mainly focused on the development of new technologies for a car's dashboard.
The findings of the study have been iteratively discussed and refined together with the project participants, and the vision for the value simulation approach has been developed and verified in collaboration with the project members.

3 ASSESSING VALUE IN THE CONCEPTUAL DESIGN PHASE

A new car's development is guided by project management practices (Midler, 1995), usually with several gates where specific decisions have to be made, and with strict timelines to adhere to. This model is often referred to as a Stage-Gate® process (Cooper, 2011), commonly used to drive the development process from idea to product launch. The elements of the model are the *stages*, where information-gathering activities are condensed in project deliverables and *gates*, where the information is assessed and decisions are made.
Empirical studies in the aerospace industry (Johansson et al., 2011), an industry with complex and long development projects, which have similarities with the automotive industry, have shown that value-related information is usually not reported at gates in a clear manner, thus vale-conscious decisions are difficult because of lacking documentation to support the design choice.

3.1 What is value?

Today the "greatness" of a design solution in the development in a new car model is mainly expressed as technical performances and cost. One of the participants in the project has described: *"what you present is usually geometrical specifications, technical functions and costs".* Furthermore, knowing what is going to be expected by the decision makers early set the mindset for the design team on what is expected to be outcome. *"You already know the set, so you prepare yourself. You know you have to put numbers on how much it weighs, and how much it costs".*
In literature there are many definitions on what constitutes value, and what value a design team should consider in their decision-making process.
Lindstedt and Burenius define customer value with the following expression (Lindstedt and Burenius, 2003):

$$\text{Customer Value} = \frac{\text{Perceived customer benefits}}{\text{Use of customer resources}} \quad (1)$$

Where customer resources can be interpreted as money, time and effort.
However very clear from a theoretical perspective, the definition needs to be turned into a more concrete and operational state. Business is also said to be all about customer value, or actually the organizations ability to create unrivalled customer value. Some people have the ability of understanding and making value-oriented decision, by experience, instinct, or training. However, based on their experiences with product development processes in Swedish and International companies, Lindstedt and Burenius state (p.14) "*The capacity of a whole organization to make correct decision demands more than good instincts of a few individuals. To succeed, the concept of customer value must be turned into a concrete, measurable element that can be put to practical use, thereby providing a guiding light in all aspects of work".*
The concept of Value Driven Design (VDD) is a Systems Engineering strategy that has been developed in the recent years mainly in the aerospace sector (Collopy and Hollingsworth, 2009). The main goal of the approach is to find the design through a value analysis, rather than a design that "just" meets the requirements. In the framework, no requirement is set *a priori*, but instead the team is asked to maximize an objective function that converts the different design attributes into a value score. Literature unfolds the main benefits of VDD, stating that the framework would help to achieve system optimization and to reduce cost erosion (Curran, 2010).

VDD (Richardson et al., 2010) assigns numerical scores to an objective function (*Value model*) so that if an alternative is better than one other receives a higher score. The attributes of the system (*Value attributes*) describe what the design has to deliver to the relevant stakeholders (defined as the outer environment of the design), whereas the design parameters of the system (*Design attributes*) are primarily of interest for engineers and describe the inner environment of the design. In complex system characterized by a long lifecycle, value is dependent by the tangible components of the system (e.g. the vehicle) and dynamic operational context (e.g. the customer journey). Value is then considered as the capability of maintaining and improving the functions in the presence of change (Ross et al., 2008). Tradespace exploration (Ross et al., 2004) considers customers in the relation to the customer process context.
In sectors such as the car market value is often considered intangible and highly related to the customers' perception of the self as well as related to past memories and it is highly affected by group dynamics (Norman, 2007) (Andriessen et al., 2000) (Daum, 2003). Conceptual models to assess the intangible value exist (Steiner and Harmon, 2009), even though the complexity of the subject is in need of more research (Sullivan and McLean, 2007).

3.2 Models, simulations, prototypes

The use of modeling and simulation techniques is well established in traditional mechanical engineering processes to efficiently analyze the physical behavior of a complex system, since the use of computers opens up to faster iteration loops and assessment (Sellgren, 1999). In the innovation engineering domain, "Serious play" (Schrage, 1999) brings real-world examples of how the World's best organizations model, simulate and prototype in order to innovate. It is argued that the most important value of modeling and simulating activities does not reside in the results that these models or simulations generate, but rather in the discussion, arguments, consultations they generate and trigger. The main idea is that the prototypes that the organization creates reflect their perception of reality, as well as the organization's own internal assumptions about risk and reward. Additionally, what the company choose *not* to model is equally important, since it might reveal internal taboos or assumptions unconsciously left out because they are the most threatening to their sense of themselves (Schrage, 1999). The process of early modeling and simulating turns the innovation cycle inside out: instead of using the innovation process to come up with a finished prototype, modeling and simulating "quick and dirty" prototypes will lead the innovation process, building upon the existing prototypes, enabling the capacity of raising questions and to generate new solutions and business models.
Literature highlights and suggests the importance of modelling and simulating the current and future state of a company, in order to avoid negative impacts of early design decision too late in the product development process (Barton et al., 2001) (Nergård et al., 2009). The whole idea is to setup and run simulations of a product-service system's performance (in all aspects, i.e. economic, ecologic, social, technical, intangible etc.) early in the design cycle and base design decisions on the simulation outcomes. This Simulation Driven Design approach (Bylund et al., 2004) is in contrast to using simulation towards the end of the design cycle, prior to prototype and testing or even just prior to design release, to validate and verify performance of the system. Hence, there are great possibilities to drive, rather than merely verify, innovative design concepts.
Business Process Modeling (BPM) (Scheer, 2000) is a Systems Engineering methodology that has the purpose of representing processes within an enterprise, in order to improve process efficiency and quality. Modeling and simulation in BPM allows pre-execution of "what-if" analysis (Laguna and Marklund, 2005) (Tumay, 1995), with the purpose to seek for an optimization of the process.

4 SCENARIO EXAMPLE: VALUE SIMULATION OF A CAR DASHBOARD

In the conceptual phase of a new car development, the vehicle is broken down in sub-systems (such as cockpit, chassis, door), broken down into the components of the system, following techniques commonly used in Systems Engineering (Schlager, 1956) practices. Figure 1 presents an instance of such decomposition, and the position of the dashboard in the breakdown can be visualized.
Furthermore, the OEM and its suppliers that are involved in the design of the cockpit are involved in different markets, and the stakeholders that influence their business, and the stakeholders they refer and are interested to might be different.
The car market is a highly evolving industry, where the OEM primarily acts in Business to Consumer (B2C) markets. The car provides value along a customer journey where the customer has complex

interactions with other individuals, organizations, services or physical artifacts that are within or without the control domain of the OEM. Customer attributes value on they customer journeys not only on the performance features of the car but also on emotional and conditional feelings. The B2C markets are characterized by rapid changes over time, and in some cases customers spontaneously start new business models using the car as a platform, as in the case of peer-to-peer car sharing.

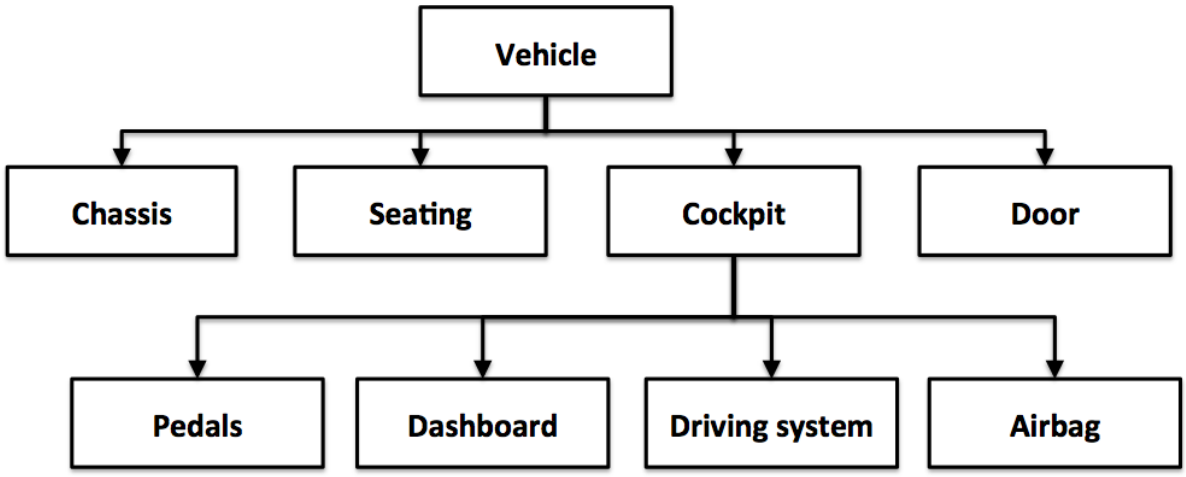

Figure 1. Instance of the breakdown of a vehicle

Suppliers develop products together with the OEM but are at the same time actively involved in other B2C or B2B (Business to Business) markets. In some cases, they are interested to use the component or the technology they are developing as a platform to increase sales in markets that do not belong to the automotive industry.

The Value Network (Allee, 2000) is thus complex and different stakeholders are involved.

Figure 2 shows an instance of the Value Network taking for the sake of simplicity the case that the OEM and two suppliers are involved actively in the actual design of the dashboard in the conceptual phase. The Value Network comprises other seven stakeholders, and the interests are different between the different companies. For example, the first and the second supplier would like to open business opportunities with construction equipment companies with the new technologies that will be enabled in the dashboard (e.g. Augmented Reality).

New groundbreaking features are expected to be present in the cars of tomorrow. Many of these technologies are competing with each other and it is very difficult to predict which will be the winner. Cars are expected to have autonomous drive, to turn electric and to communicate with other vehicles in the surrounding infrastructure and hence acting as a safety means. Cars will also be able to track our use habits in order to automatically customize the interior and exterior based on our preferences.

Given this context, it becomes challenging for the design team responsible for the design of the cockpit to understand how the design of a component (such as the dashboard) could contribute to the highest value in five or ten years in the automotive or construction equipment industry. It is even more difficult to understand the impact of the components in relation to new business models. Revisiting the example provided in the introduction, an add-on feature such as GM's On Star system used for emergency calls becomes now crucial to determine the success of a new business model (such as peer-to-peer car sharing) and then open up entirely new opportunity for the car company to be a firs-mover in the new market.

For a design team designing new technologies and features for the dashboard becomes less intuitive to position the component in the overall system, and considering the stakeholders' needs in the view of new business models. For example, in a traditional business model a touchscreen and Augmented Reality might provide customer delight and thus the great value. The combination of the dashboard with a system of sensors and software that is able to mine data and give information about the state of the car (state of maintenance etcetera) displayed trough the dashboard might help the user to lend the cars to other people and to attract "skeptic car borrowers" (people that would like to borrow the car but are afraid of not knowing how the car has been used). Conversely, in a traditional business the user might not perceive the information so valuable, since she knows the state of the car and how it is has

been used, since she is the only user of the car. Thus the software might be perceived only as costs and an unwanted function.

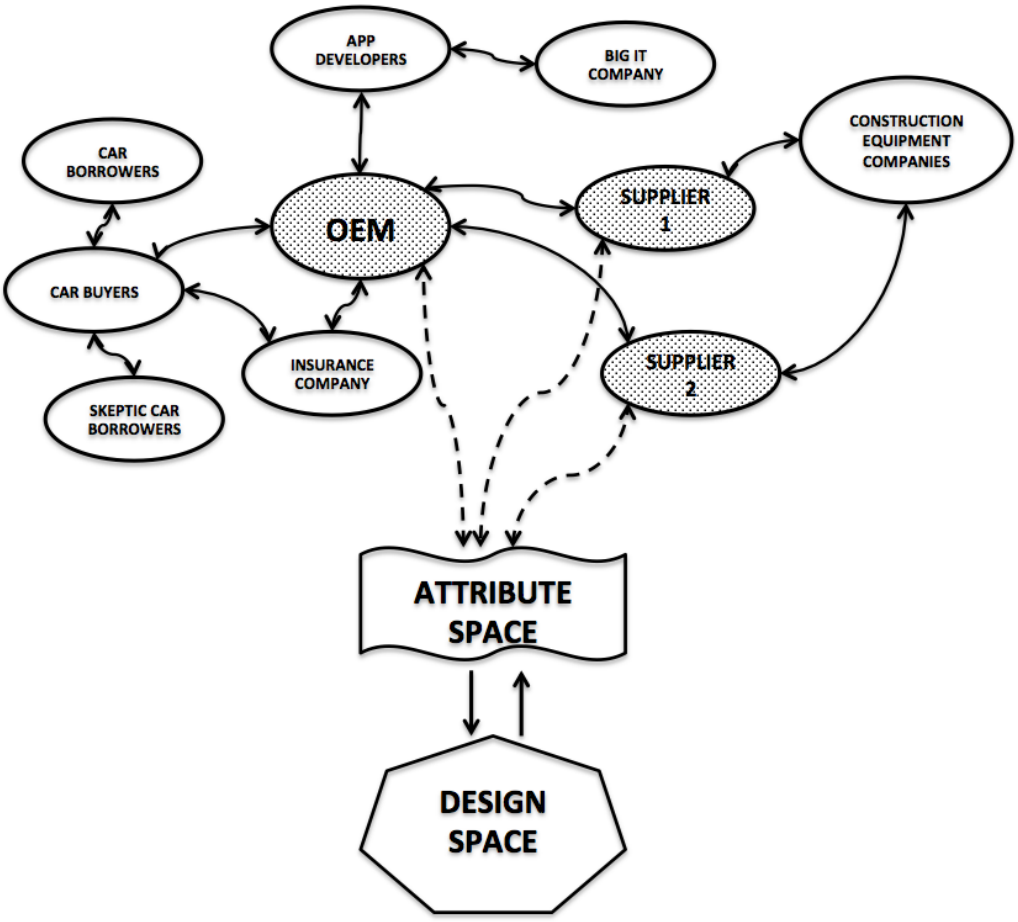

Figure 2. Value Network and stakeholders involved in the development of a car dashboard

Considering the complexity and the challenges involved in the design decisions, it appears clear that considering value-oriented issues becomes challenging for an Engineering design team. Collaboration in conceptual phases with other professionals working closer to customers (such as Marketing and sales) is often lacking (Damian, 2007). The importance of this cooperation has been pointed out by one of the participants in the project: *"without sales and marketing and such, it is very difficult to get important feedback into the project from potential customers".* Commercialization aspects of a new technology are perceived to be taken too late in the downstream process. The considerations of these issues in the early stages are difficult, since Engineers usually do not have enough competence in those domains, or the competences and documentation requested to Engineers are expected to be too broad that at the end they become very difficult to manage within the project timeframe. Another participant in the project has pointed out on this regard: *"at the end, it becomes more paper work and Powerpoint than Engineering".* Hence, the value consideration for the different stakeholders is often left to the individual's own capability to make the right decisions.

Additionally, time to dedicate to customer-value related activities and thoughts is often scarce, and one of the crucial factors is considered to be the ability of the project team to trust the work in an open way, and increase the degree of freedom.

These reflections suggest a need for an approach that integrates traditional design requirements with more qualitative dimensions being able to assist a design team in taking more value-oriented decision in the conceptual design phases. The authors have developed a conceptual scenario using the development of a car dashboard as a case study.

Figure 3 shows the actors involved in the project, the series of activities and the documentation needed in the scenario. The phases can be considered to be mapped alongside the activities usually performed in the Stage-Gate ® process (Cooper, 2011).

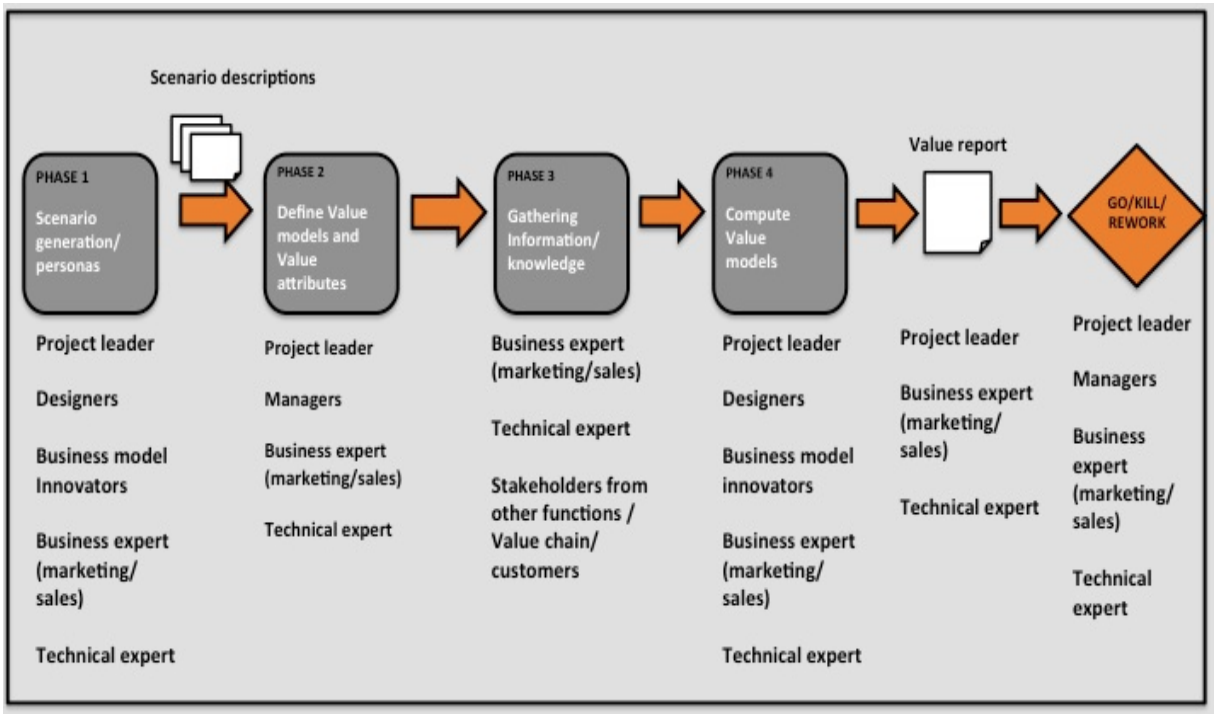

Figure 3. Scenario phases

3.1 Scenario generation/personas

The scenario begins with creative workshop within the design team. These workshops assume the form of multi-disciplinary work where designers are integrated with professionals (called "Business model Innovators" in the scenario), coming from other departments, such as marketing and sales. Tools and methods used in this phases are Scenario-Based Design (Carroll, 2010), Kano Model (Kano et al., 1984) or Business Model Canvas (Osterwalder and Pigneur, 2010). The objective of this work is to identify possible customers, their real needs and expectations and possible actors involved in the process. The objective of this phase is also to have a general and shared view of what can be possible both from the business and technical side. The teams are encouraged to work with a high degree of freedom. The phase ends with a generic description of the possible scenarios; the teams can share the canvas and the personas in an easy way (though the use of games displayed with a smartphone app, for example) and have this generic information tangible in the walls of their offices.
In 2nd phase two experts; one Business expert and one Technical expert are assigned as responsible for the value assessment process, and their purpose is to mutually collaborate making sure that the process is performed, while supporting each other, showing what is possible from the two different sides.

3.2 Define Value models and attributes

Value models for the different personas are then defined based on generic needs related that the customer has along her/his journey. A list of eight of this needs for the *car buyer* can be *performance, driveability, safety, durability, security, reliability, customer image, profitability.* The need *profitability* is consider one "exciter" for the car buyer in the scenario, considered a young customer with the willingness of earning money with the car. The project leader together with the Business and Technical expert list also the current cost drivers that the customer has along his journey: *Fuel, insurance, depreciation, financing charges, maintenance and reparation.* Different needs are more important than others, thus the team has to assign weights on needs and on costs, based on their impacts on customers. The project leader and the managers can then define a list of Value Attributes, both for the designers and the Business Model Innovators. Value Attributes are generic life-cycle oriented parameters applicable to products and business of different kinds. The team of managers has also to assign weights on the different Value Attributes based on their ability to satisfy the customer's needs.

3.3 Gathering Information/Knowledge

In this phase, The Business and the Technical experts jointly start to gather value-related information from stakeholders and other relevant sources for the Value Analysis. This information cannot be considered only based on cost and sales information, but has to contain prevision trends (such as the estimation of peer-to-peer users in 2020), or customer acceptance based on customer surveys or direct feedback. Technical information about new technologies is fundamental, as well as information about new regulation in terms of emissions.

This information is very dispersed along the supply chain, and trust and cooperation between the different partners in needed. In the automotive industry, is very important that the OEM supports and drives the process, since usually is the main stakeholder and usually is also the actor with the highest resource capability in the Value chain.

If information is difficult to gather because of privacy, security and IPR issues the two experts can ask for a qualitative feedback based on given set criteria.

Where needed, Business Process Modeling simulations are performed, and the Business expert can request the aid of the Business Innovators that had participated in the scenario generation phase.

3.4 Computing Value models

The project leader, the Business model expert and the Technical expert assist the design team of assessing the value contribution of the different design alternatives comparing the different scenarios generated in the idea generation phase. The output of the value analysis is given in form of scalar from 1 to 9, which tells the degree to which the design moves itself to a baseline score (considered to be related projects characterized by incremental improvement) and the target score (considered to be customers "feel free to dream" expectations expressed during the feedback moments or based on long-term forecasts). This way of considering and computing value has been studied, tested and implemented in recent studies within the aerospace industry (Bertoni, 2012). The value analysis is then given to the designers and suggestions for future improvements (as well as appreciations for highly value-oriented designs) are discussed and defined.

3.4 Value reporting and analysis at the gate

The value contribution of the components in relations to the different scenarios is then collected in a *Value Report*, which summarizes the most relevant information for the decision makers, and the degree of confidence of the data collected.

The report is then enclosed to the common technical deliverables and forwarded to the management team, who will analyze them in the gate meeting. In this phase, the project team will review the material and discuss together with the project team and the two experts who acted as Value analysts about the value contribution of the different options, and additional analysis is requested if needed. Eventually the gate is opened and the expectations for the next gate are communicated to the project manager and resources are allocated.

5 CONCLUSIONS AND FUTURE WORK

Supply chain collaboration and involvement in the preliminary stages of the design of a new car model is very important in order to achieve a better and more effective way of working.

However, in a rapidly changing environment such as today's automotive industry, it is very difficult for a design team to consider the impact of their design choices on the value for the different stakeholders, as well as to consider the design's value in relation to future scenario and business models.

Compliance to technical and cost requirements are the main deliverables requested to engineers at decision gate meetings, and it is also difficult to map, discuss and consider the contribution of the design to the value for the complex constellation of stakeholders.

Cooperation with other professional working closely to customers, such as marketing and sales, is often scarce at these stages, and the time to dedicate to value-related activities is considered limited.

This calls for an approach that puts more qualitative measures alongside the technical requirements, in order to give a better understanding and awareness to the designer of the impact of their design decisions on the overall system, as well as the value for different stakeholders and in future scenarios.

This paper has presented an approach aiming at overcoming the underlined challenges. A conceptual scenario has been described pointing out the key elements and actors involved. The main idea of the

scenario is that the assessment of the design in relation to future scenario and business models is driven by gathering value-related information during the stage activities, and the activities are coordinated by the synergic work of a Technical expert and Business expert.
Future work will be to test the approach in real case application, and to integrate the approach with more quantitative data.

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REFERENCES

Allee, V., 2000. Reconfiguring the value network. J. Bus. Strategy 21, 36–39.
Alonso-Rasgado, T., Thompson, G., Elfstrom, B.O., 2004. The design of functional (total care) products. J. Eng. Des. 15, 515–540.
Andriessen, D., Tissen, R., Tissen, R.J., 2000. Weightless wealth: Find your real value in a future of intangible assets. Financial Times/Prentice Hall.
Baines, T.S., Lightfoot, H.W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., others, 2007. State-of-the-art in product-service systems. Proc. Inst. Mech. Eng. Part B J. Eng. Manuf. 221, 1543–1552.
Barnes, T.A., Pashby, I.R., Gibbons, A.M., 2006. Managing collaborative R&D projects development of a practical management tool. Int. J. Proj. Manag. 24, 395–404.
Barton, J.A., Love, D.M., Taylor, G.D., 2001. Design determines 70% of cost? A review of implications for design evaluation. J. Eng. Des. 12, 47–58.
Bertoni, A., 2012. Value assessment capabilities in early PSS development a study in the aerospace industry.
Botsman, R., Rogers, R., 2010. What's mine is yours: The rise of collaborative consumption. HarperCollins e-books.
Bylund, N., Isaksson, O., Kalhori, V., Larsson, T., 2004. Enhanced engineering design practice using knowledge enabled engineering with simulation methods, in: Proceedings of the International Design Conference, Dubrovnik, 18–21 May.
Carroll, J.M., 2010. Scenario-based design. Int. Encycl. Ergon. Hum. Factors -3 Vol. Set 198.
Collopy, P., Hollingsworth, P., 2009. Value Driven Design. American Institute of Aeronautics and Astronautics, 1801 Alexander Bell Dr., Suite 500 Reston VA 20191-4344 USA,.
Cooper, R.G., 2011. Winning at new products. Basic Books.
Curran, R., 2010. Value-Driven Design and Operational Value. Encycl. Aerosp. Eng.
Damian, D., 2007. Stakeholders in global requirements engineering: Lessons learned from practice. Softw. Ieee 24, 21–27.
Daum, J.H., 2003. Intangible assets and value creation. Wiley.
Hampshire, R.C., Gaites, C., 2011. Peer-to-Peer Carsharing. Transp. Res. Rec. J. Transp. Res. Board 2217, 119–126.
Johansson, C., Hicks, B., Larsson, A.C., Bertoni, M., 2011. Knowledge maturity as a means to support decision making during product-service systems development projects in the aerospace sector. Proj. Manag. J. 42, 32–50.
Kano, N., Seraku, N., Takahashi, F., Tsuji, S., 1984. Attractive quality and must-be quality. J. Jpn. Soc. Qual. Control 14, 39–48.
Katzev, R., 2003. Car sharing: A new approach to urban transportation problems. Anal. Soc. Issues Public Policy 3, 65–86.
Laguna, M., Marklund, J., 2005. Business process modeling, simulation, and design. Pearson/Prentice Hall.
Lewis, A., Simmons, M., 2012. P2P Carsharing Service Design: Informing User Experience Development. Thesis submitted for completion of Master in Sustainable Product-Service System Innovation, School of Engineering, Blekinge Institute of Technology, Karlskrona, Sweden. http://p2pcarsharing. us. com/wp-content/uploads/2012/08/P2P-Carsharing-Service-Design-Lewis-Simmons. pdf (Zugegriffen 10.

Lindstedt, P., Burenius, J., 2003. The value model: how to master product development and create unrivalled customer value. Nimba.
Meier, H., Roy, R., Seliger, G., 2010. Industrial Product-Service Systems–IPS2. Cirp Ann.-Manuf. Technol. 59, 607–627.
Midler, C., 1995. "Projectification" of the firm: The Renault case. Scand. J. Manag. 11, 363–375.
Nergård, H., Sandberg, M., Larsson, T., 2009. Towards life-cycle awareness in decision support tools for engineering design, in: Proceedings of International Conference on Engineering Design, Stanford, USA.
Norman, D.A., 2007. Emotional design: Why we love (or hate) everyday things. Basic Books (AZ).
Osterwalder, A., Pigneur, Y., 2010. Business model generation–a handbook for visionaires, game changers, and challengers. New York: Wiley.
Ross, A.M., Hastings, D.E., Warmkessel, J.M., Diller, N.P., 2004. Multi-attribute tradespace exploration as front end for effective space system design. J. Spacecr. Rockets 41, 20–28.
Ross, A.M., Rhodes, D.H., Hastings, D.E., 2008. Defining changeability: Reconciling flexibility, adaptability, scalability, modifiability, and robustness for maintaining system lifecycle value. Syst. Eng. 11, 246–262.
Scheer, A.W., 2000. ARIS: business process modeling. Springer.
Schlager, K.J., 1956. Systems engineering-key to modern development. Ire Trans. Eng. Manag. EM-3, 64–66.
Schrage, M., 1999. Serious play: How the world's best companies simulate to innovate. Harvard Business Press.
Sellgren, U., 1999. Simulation-driven design: motives, means, and opportunities. KTH.
Shaheen, S.A., Cohen, A.P., Chung, M.S., 2009. North American Carsharing. Transp. Res. Rec. J. Transp. Res. Board 2110, 35–44.
Steiner, F., Harmon, R., 2009. The impact of intangible value on the design and marketing of new products and services: An exploratory approach, in: Management of Engineering & Technology, 2009. PICMET 2009. Portland International Conference On. pp. 2066–2079.
Sullivan, P.H., McLean, R., 2007. The confusing task of measuring intangible value. Intellect. Asset Manag. 23, 36–41.
Tukker, A., Tischner, U., 2006. New business for old Europe. J. Clean. Prod. 2.
Yin, R.K., 2008. Case study research: Design and methods. SAGE Publications, Incorporated.