Proposition of a SofS Product and Service System design methodology in the context of new mobilities for an OEM

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*System of System design methodology, Product and Service System Design, Complex system design, Business model development*

Research domains:
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Context: Issues and stakes

Large-scale uptake of a shared and self-driving fleet of vehicles is considered to be changing the face of European cities. It is even more important to consider this fact as car are underutilized resources in view to future sustainable development. They are used less than an hour per day, their capacity is underused; often time they display less than one occupant per trip. Recent report of the International Transport Forum at the OECD has underlined that the same personal mobility can be obtained with 10% of the cars (OECD 2015). Several major potential changes have been underlined. It is considered that Taxi boots with high level public transport systems could potentially remove 9 out of 10 existing cars. However, the overall car travel will be likely increasing. The overall volume of the car travel is likely to increase (for instance for taxi-boots with 6% more car-kilometer travelled then today as they might compete with buses; and for AutoVot in the case of absence of transports the car-kilometer travel will have an estimated increase +89%). The parking space is considered to be diminishing and will open significant public and private space. These services are estimated to be increasing up till 18% of more TaxiBoots and 26% more of AutoVots in the case where a preexisting high capacity public transport is existing; and in a case where there is no preexisting high capacity transport it is considered to increase around 13% and 24% respectively in car kilometers travelled.
These changes are actually dependent on the technology that will be used and implemented in the development of these new cars. Moreover, the increase in use of these cars will depend heavily on the services that are provided in relation to these self-driving cars. Even though it is considered that the congestion might decrease this is considered, by all experts in the field, as heavily depending on the configuration of the transportation system as well as services that are proposed as an essential part of the new transportation system. In terms of policy recommendation with regard to these changes, it is considered that new vehicle types (integrating different types of technologies) and related business models will be required (OECD 2015).

These estimations and changes are of course global. As discussed previously the major variables in these developments are transportation system configurations, new types of vehicles that will be developed, new transportation services that will be proposed in relation with new vehicle types, and new business models that might considerably change the market competition. All studies underline the need for a systematic or systems approach to the problem as these problems are coupled and changing concurrently. In many studies, the underlining fact is the need to create truly integrated systems (or System of Systems) with the emphasis on the choice, flexibility and connectivity (Forum_for_the_Future, FIA_Foundation et al. 2016).

Designing complex systems raises particular challenges for designers such as modelling inherent couplings, incorporating uncertainty modelling, large-scale optimization, multi-disciplinary design optimization and emergent behavior (Minai, Braha et al. 2006, Bloebaum and McGowan 2010). Distinct and adequate support (Allen, Azarm et al. 2011) is required to link across multiple domains, areas of expertise and use scenarios. Product and service approaches or Service-oriented product development strategies have been developed recently to support conjoint development of a service and a system (Tan 2010). Moreover, they have been extended in order to address Product and Service System Design (for example ongoing work at AFIS Association Française de l'Ingénierie Système, (Tan 2010)). However, in majority of cases these approaches have been considering a product/system development and not necessarily integrated systems such as transportation systems where an approach of System of Systems is needed. This is due to the fact that not only a coupled service and product approaches need to be considered but also their integration in the transportation system that is yet to be defined and is depending on future rapid development of new technologies.

Research project definition
In order to address the previously discussed questions, one can identify three main activities/research questions:

1) Characterizing the degree of “servitization” yielding the taxonomy of Product Service Systems in the case of autonomous vehicle development

In recent years, an effort has been made in order to characterize product and service development. Tukker and Tischner (Tukker and Tischner 2006) consider these developments from a business perspective. They propose a characterization of these with regard to the business perspective (see figure 1).
However, it is unclear what degree or “servitization” can be possible in the case of integrated transportation system of systems and how this is influencing future PSS developments. In particular, this is also due to the fact that transportation systems are still developing and their future configuration will largely depend on the new technologies; hence the need to integrate these uncertainties in the PSS taxonomy. In this case, there is a need to further investigate possible degrees of “servitization” with regard to new technologies and new vehicle types design. This work should be done in coherence with already existing work in the scientific literature as well as current work ongoing in AFIS on Product-Service System design.

On the other hand, PSS development orientation may be influenced by the way service and product development are synchronized. Depending on the context, PSS can be part of a global development from the beginning, or needing some change of an existing product, or designing the features of a future product platform able to support services.

2) Developing a methodology to support SofS PSS development

Existing methodologies for the PSS development start from the definition of the system perimeter in order to be able to integrate constraints from the entire life cycle. However, the question that is essential in this case is what is the perimeter of the PSS development. This perimeter is depending on and is coupled with the future development of the infrastructures and transportation system (i.e. System Of Systems). Therefore, this boundary is uncertain. In this case, the question is how to support the development activities of SofS PSS systems while integrating the flexibility in determining the boundaries that will be influenced by integrated system development (such as IoT Internet of Things, Smart cities, etc.).

Agile System Engineering approach should be investigated, because System Engineering might not be able to address some features of this kind of services, and because Agile may not fit with automotive systems and product line management.

Competencies and the interest of integrated research departments for the research project

Laboratoire de Génie Industriel (LGI) is one of the major departments in Complex system design and at CentraleSupélec. More than 90 faculty and 50 PhD students, 11 research and education chairs, demonstrate the research and education activity and its intensity. Research team Design Engineering
with its 26 researchers is organized around 4 major research axis: Design of complex systems (Airbus, Thales, Renault, PSA, etc.); Design of sustainable systems (PS2E, Alstom grid, Air Liquide, CEA); Complex project management (Total); and Innovation engineering (Paris town, Schneider Electric, SilverValley).

Design of complex systems aims at developing methods and tools supporting decision-making with regard to design of products and organizations. The focus is on enhancing numerical capabilities and simulation processes for preliminary and early design stages addressing system architecture, system configurations, value engineering, trade space explorations, etc. Design process modeling is therefore a critical issue organized around collaborative design, collaborative simulation, and technology and knowledge transfer.

In this area we have been developing decision support and simulation methods to support System Architecture design (Moullec, Jankovic et al. 2012, Vosgien, Nguyen Van et al. 2012, Moullec, Bouissou et al. 2013, Ben Hamida, Jankovic et al. 2015, Jaber, Marle et al. 2015, Ye, Jankovic et al. 2015, Jankovic and Eckert 2016). Research projects addressed both system architecture processes, the difficulties that companies may have as well as development of adapted methods and tools. Research has always been rigorously tested and validated in operational conditions.

Organization of simulation process as a support for system design and system architecture design has been also investigated (Vosgien, Jankovic et al. 2011, Vosgien, Nguyen Van et al. 2012, Sirin, Coatanéa et al. 2013, Sirin, Paredis et al. 2015). When addressing system design both technological system have been considered (Sirin, Coatanéa et al. 2013) as well as organizational systems such as healthcare systems and innovation integration in this context (Jean, Jankovic et al. 2015).

The integration of sustainable design factors have been considered early in design (Ye, Jankovic et al. 2015). Methods were proposed allowing for predictive modelling and simulation estimating overall system architecture parameters as well as sustainable design parameters. The support aims at selecting system architectures with adequate performances and minimizing the impact on the environment.

Value Driven approaches have also been one of the focuses of the research. Approaches linking value driven design and system architecture design have been investigated in several contexts (Hein, Jankovic et al. 2015, Ben Hamida, Jankovic et al. 2016). Moreover, a methodology to support value driven design is currently being tested within a PhD study in Astrium, now Airbus Defense and Space (Ben Hamida, Grandou et al. 2015, Ben Hamida, Jankovic et al. 2015).

References


