Towards a Scenario-Based Approach for an Electronic Driving Management System Architecture: A Case Study

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ABSTRACT

Electronic driving management systems are a suitable tool to control certain businesses' mobility resources and to contribute to human resource management purposes. We investigate different scenarios for such driving management in the context of electrified powertrains such as electromobility and digitization, with a regional focus on Germany. Therefore, a literature review has been conducted resulting in 50 driving scenarios that can be derived. The driving scenarios are divided into four dimensions splitting into two further categories. These driving scenarios shall build the foundation for a future electronic driving management architecture which is essential to meet the new requirements of electromobility. These requirements increase the complexity of the overall socio-technical system, making it challenging to manage electronic driving.

Keywords

Electromobility, electronic driving management, driving scenarios, electronic driving management systems

INTRODUCTION

Because of proportionally lower ranges and their more frequent need for recharging, electromobile vehicles tend to higher coordination efforts. These requirements increase the complexity and controllability of an overall socio-technical system. It does not only consists of the vehicles and the drivers themselves but e.g. of the electricity and charging infrastructure as well as the required applications and organizations that are required for operating. It is evident that metropolitan areas with high traffic density are particularly confronted with the question of how to handle the complexity.

Therefore, in comparison to previously common vehicle fleets that only based on combustion engines, electromobility sets new requirements to future system solutions. They will enable both fleet operators to adapt to the evolving conditions by reducing the coordination efforts for heterogeneous vehicle fleets. Hereinafter, we call them *electronic driving management systems* (EDMS).

In order to preserve electronic driving management (EDM) feasible, there is a need for a comprehensive, analytical – i.e., architectural approach. However, such an approach needs a holistic concept from the requirements to the maintenance and the safety and security of these information systems. In this study, we focus on identifying and analyzing driving scenarios to develop a foundation for an EDMS. Therefore, we follow the research question:

What are applicable scenarios for electronic driving management?

RELATED WORK

Digitalization drives the automobile industry to explore new business models. According to the value concept, value co-creation is one crucial factor (Riasanow, Galic and Böhm, 2017). EDM can enhance value co-creation. Withal, electromobility changes the traditional value chain of the automotive industry, resulting in different needs but also opportunities in comparison to traditional vehicles. To meet these needs and for generating additional value, companies tested new business models that are already in the market as well as new entrants. New business areas prospectively include, e.g., charging station production, installation and maintenance, data management and automated billing or platform-based information services (Amsterdam Roundtable Foundation and McKinsey& Company The Netherlands, 2014). Figure 1 gives a simplified overview of the current market situation along with an electric vehicle (EV) value chain.

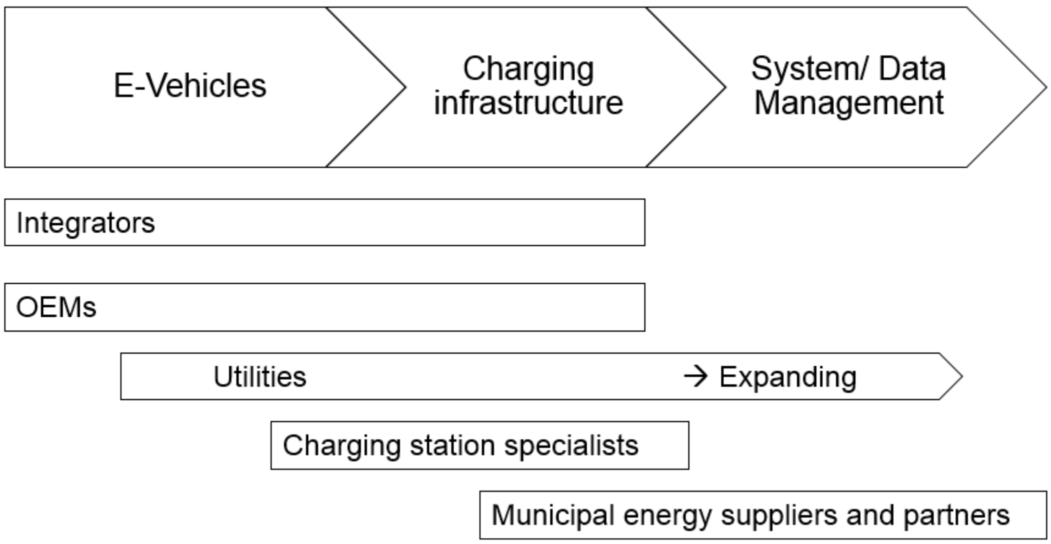

Figure 1. Market Incumbents and New Entrants along the Electric Vehicle Value Chain (Amsterdam Roundtable Foundation et al., 2014)

The term "electromobility" generally refers to technology concepts that include a (partially) electrified powertrain. Six categories classifies these vehicles based on their implementation percentage of electrification:

First and second, the Micro and Mild hybrids, in which a parallel-mounted electric motor supports a primary combustion engine. While micro-hybrids are limited to support during the starting process, mild hybrids contribute to increasing the drive efficiency by operating in parallel with the primary engine. Third, full hybrids drive enables partial, purely battery-electrical overcoming of sections. If certain parameter limits are exceeded, e.g., a speed limit, an internal combustion engine is switched to it. Forth, plug-in hybrid electric vehicles (PHEV) compared to the hybrid drive concepts; it is possible to charge the energy storage device of the vehicle via an external interface. Fifth, PHEVs with a primary electric drive and a switchable combustion engine to extend the range are referred to as Range Extended Electric Vehicles (REEV). Six, (only) battery-electric vehicles (BEV) have a purely electric drive concept. We focus on PHEV, REEV, and BEV according to the highly delegated German National Platform for Electromobility (“Nationale Plattform Elektromobilität”/ NPE)[1] (Nationale Plattform Elektromobilität, 2018).

The process of how to manage heterogeneous vehicle fleets highly depends on the mobility concepts that have to be realized. The usual combination of application scenarios which comprises of commercial, individual and public transport is increasingly complemented by integrated concepts such as car-sharing services which have become more and more popular over the last 30 years (Shaheen and Cohen, 2008). This trend changes the mobility behavior in Germany, characterized by a more variable choice of means of transport (*multimodal mobility behavior*) (Kagerbauer, Schuster, Hertweck and Wolf, 2014).

[1] The NPE was recently transferred into its successor organization, the National Platform Future of Mobility (“Nationale Plattform Zukunft der Mobilität”/ NPM).

In this context, a survey from the Fraunhofer Institute for Systems and Innovation (Fraunhofer ISI) has revealed that from a customer's point of view, using electro mobile vehicles for public transport, car sharing services, and integrated concepts[2] appears to be promising (Federal Ministry of Transport Building and Urban Development BMVBS, 2012).

Table 1 highlights the related survey results.

Usage scenario of electro mobile vehicles	Agreement
Commercial transport	47%
Individual transport	58%
Public transport	70%
Car sharing/ rental concepts	69%
Integrated mobility concepts	70%

Table 1. Estimates for Electromobility-Specific Mobility Scenarios (n= 2306) (Federal Ministry of Transport Building and Urban Development BMVBS, 2012)

At this, further legal aspects have to be included. Driving Logbooks are an integral part of driving management systems, for instance. For a tax-compliant use of digital logbooks in Germany, it is mandatory to take technical measures so that changes in the dataset are transparent or completely excluded (Foerster, 2012). Consequently and with particular regard to the European General Data Protection Regulation (GDPR), the digitalization of driving management processes makes high demands on the data security (Office Journal of the European Union, 2016).

An EDM architecture helps to understand the requirements of electronic vehicles by and to assess new business models better. As such an integrated methodology supposedly creates transparency and identifies complex interrelationships, it appears to be a suitable tool for further actions. Figure 2 highlights the research focus of this study.

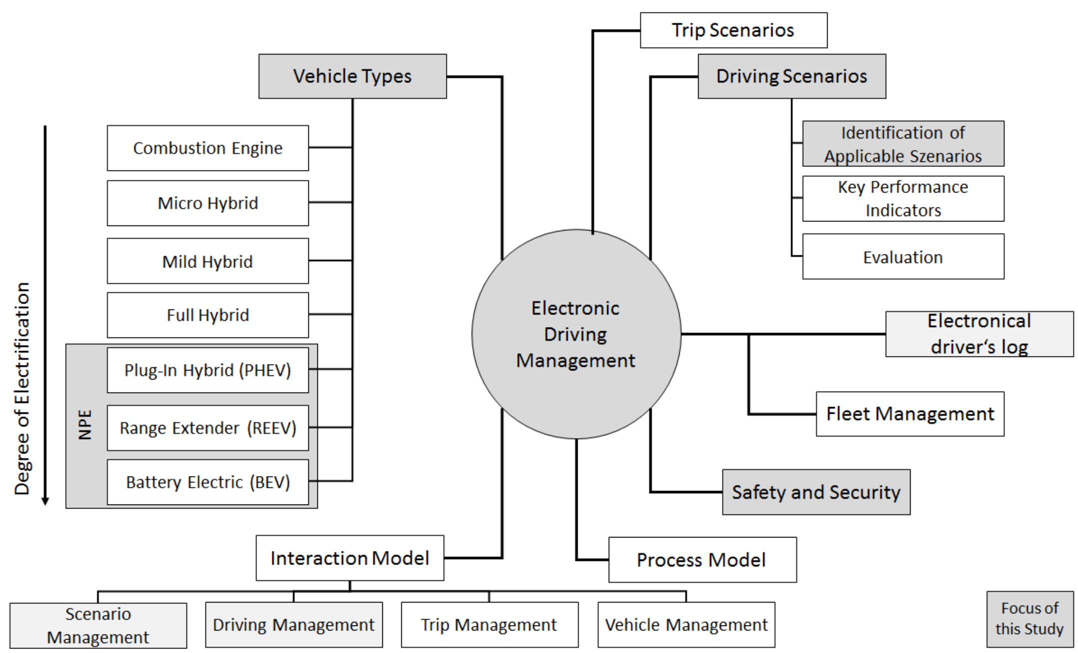

Figure 2. Research Focus

[2] According to the Fraunhofer ISI, an integrated mobility concept is the combination of different transportation methods, e.g. bus and train traffic or sharing services.

METHOD

We conducted a literature review according to Webster and Watson (2002) to come from an author-centric to a concept-centric approach. Therefore, we coded the literature into three concepts (*Organization*, *Usage*, and *Trip*). From these findings, we derived a concept-matrix consisting of four dimensions of driving scenarios. The fourth dimension represents the applicable mobility concept. Finally, we examined the three dimensions in detail. Figure 3 presents the method approach to this study.

1	**Literature review** Keywords: e-mobility, fleet management, driving logbook, electrified mobility, electrified fleet management Sources: Google Scholar, Microsoft Academic, WebOfScience
2	**Dimensions of Applicable Driving Scenarios** Coding: • Organization • Usage • Trip
3	**Mobility Concept**

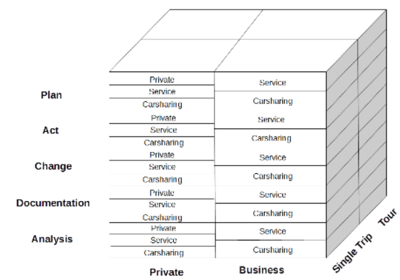

Figure 3. Research Method

RESULTS

We depict four dimensions of driving scenarios: *Organization*, *Usage*, *Trip,* and *Mobility Concept*.

The dimension *Organization* focusses on the driving management process. This dimension separates five iterative steps: *Plan*, *Act*, *Change*, *Documentation*, and *Analysis*. These, in turn, derive from the PDCA (Plan Do Check Act) Deming Cycle Phases. We adapted the steps to the current driving management circumstances. The dimension *Usage* distinguishes between Private and Business situations. The usage of the vehicle depends on the situation. For the situation *Private*, there are three ways of how the vehicles are provided for the trip: private, service, car sharing. *Private* constitutes the situation that the driver uses his privately-owned car. At *service* situations, the service provider where the car can be reserved makes the vehicle available. The situation *car sharing* constitutes situations where the care is made available for the trip by using a car sharing service. The *Business* situation depicts two categories of vehicle providing: Service and Carsharing. These two categories are equal to those in private situations. The dimension *Trip* includes either a single trip from point A to point B or several trips in the form of a tour that can be carried out with a vehicle. In whole 50 driving scenarios were identified.

Table 2 illustrates an extract of the driving scenarios. Because of a lack of space, the table does not include all driving scenarios, but the concept gets clear[3].

No.	Organization	Usage	Trip	Mobility Concept
S01	Plan	Private	Single	3 options: (1) private vehicle usage (2) service vehicle usage (3) car sharing vehicle usage
S02	Plan	Private	Tour	3 options: (1) private vehicle usage (2) service vehicle usage

[3] The authors provide the whole table on request.

No.	Organization	Usage	Trip	Mobility Concept
				(3) car sharing vehicle usage
S03	Plan	Business	Single	2 options: (1) service vehicle usage (2) car sharing vehicle usage
S04	Plan	Business	Tour	2 options: (1) service vehicle usage (2) car sharing vehicle usage
…	…	…	…	…
S05	Act	Private	Single	3 options: (1) private vehicle usage (2) service vehicle usage (3) car sharing vehicle usage
…	…	…	…	…
S06	Change	Private	Tour	3 options: (1) private vehicle usage (2) service vehicle usage (3) car sharing vehicle usage
…	…	…	…	…
S07	Documentation	Business	Single	2 options: (1) service vehicle usage (2) car sharing vehicle usage
…	…	…	…	…
S50	Analysis	Business	Tour	2 options: (1) service vehicle usage (2) car sharing vehicle usage

Table 2. Driving Scenarios Extraction

DISCUSSION AND CONCLUSION

On the way from the homogeneous vehicle fleet, which mainly consists of gasoline and diesel vehicles, to the heterogeneous and integrated system also including electrified powertrains, there is a need of a comprehensive concept that provides new perspectives, so companies are capable of operating inhomogeneous fleets. The collection of identified driving scenarios will be an essential foundation for this. However, these are only one prerequisite that emphasizes the driver him- or herself. Thus it appears that the driving person is embedded into the respective trip situation, characterized by its' environmental aspects (e.g., service, maintenance, and expansion work, green energy supply, common charging infrastructure, range-aware disposals). By implication, both the driving management and the management of the trip with an electronic driving logbook have to be merged into an integrated EDMS.

Such an approach will encompass smart action planning, operational control, analysis and evaluation, tailored to the business needs of the fleet operators. In the understanding of a socio-technical system, it will factor current technology trends in so accumulated data can be used in a value-adding way. A viable solution path will need further research.

Simultaneously, our concepts are the result of exploratory research in a limited market and need additional validation in order to gain sufficiently general knowledge. Future work has to integrate the validation of our approach (quantitatively and/or qualitatively) and the conceptualization of solution patterns architecturally. In particular, this will include safety- and security-driven aspects for the implementation of an EDMS as an inhomogeneous vehicle fleet will presumably imply (1) numerous interfaces offering entry points for potentially malicious and/or abusive software and (2) difficulties in ensuring the systems' maintainability and the reliability resulting from different vehicles with different states of technological development over a longer period of use.

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