Iterative Evaluation of a Driver Assistant Client in ICT-Systems in the Context of Urban Logistics and Electric Vehicles

Johan Buchholz, Sebastian Apel, Christian Stolcis and Volkmar Schau

Chair of Software Technology
Friedrich Schiller University Jena, Germany
Email: {johan.buchholz, sebastian.apel, christian.stolcis, volkmar.schau}@uni-jena.de

***Abstract*—Information and communication technology (ICT) systems for electric vehicles (EVs), which support planning, monitoring and analysing urban area logistics can become complex and difficult to use. In Smart City Logistik (SCL) project a driver assistant client (DAC) was developed to help to overcome fears, limited information and uncertainty in the context of urban logistics. To evaluate the users' needs and intentions an iterative and open approach was designed and consequently used. Triangulation helped to get the best possible insights out of each of three phases of development, and the findings were used to improve the DAC. A lot of uncertainty accompanied the beginning of the project, so qualitative information was gathered to understand how the drivers work routines look like and which attitudes towards new technologies prevailed. A more quantitative approach helped to collect a broad range of opinions on specific usability topics before a final simulated system setup contributes to ask a wide variety of users their experiences. This agile and iterative approach helped to identify important aspects while designing the DAC and compare different solutions, e.g., regarding necessary functionalities, menu-structure, font, button-size, and other parameters. The implementation of these findings enabled the project partners to develop a broadly accepted user interface and system that will be used in electric vehicles in urban logistics.**

Keywords–Survey; Usability; Electric Vehicles; Simulated Environment.

I. Introduction

Since the need of delivering goods increased massively in the past decade and will increase further in the next years [2], the use of electric vehicles (EVs) for last-mile delivery could help to reduce the air and sound pollution substantially, especially in inner cities[1]. In fact, most researchers agree that even well beyond 2020, the capacity of batteries will not fit future range demands [3]. This restriction affects mainly available EVs, which are designed for the transportation of goods. Therefore, many companies have qualms to use this new technology because of range limitations, low density of recharging stations, and long charging time [4]. Nevertheless, no matter which technological restrictions appear with EVs compared to traditional vehicles, for most companies it all comes down to the ability to plan the vehicle usage, including the certainty that the planned tour can be done. In fact, many companies interviewed during the Smart City Logistik (SCL) project, have already tours within the range of an EV, or at least can adopt tours with little effort.

The research project SCL pursues the goal to develop such a system, which provides relevant information on EV-specific restrictions and helps to overcome fears and to support the usage within urban logistics. As part of the German special federal research program for Information and Communication Technologies for Electric Mobility II (ICT II) [5], the SCL project supports the integration of EVs in fleets through the usage of information and communication technology (ICT).

One of the most important parts of such a holistic system is the assistance of the driver. In a complex socio-technical system where EVs are used within urban logistics, the driver needs to cope with additional information (such as range, battery status, etc.) to fulfil his primary task of delivering goods. To reduce stress and uncertainty resulting from these important additional parameters, a driver assistant client (DAC) focussing on the needs of drivers was developed, evaluated, and implemented as a prototype during the SCL project. Therefore, a concept for technology assessment was developed, combining existing methods from social and computer sciences for the specific project. In an agile managed project, we needed to focus on methods that provided flexibility and direct user feedback. The results help to achieve the goal, to develop and improve mockup and demonstrator along the users' needs. This general concept can be applied to other projects in the field of computer-human interaction, which are confronted with similar conditions and challenges regarding uncertainty and user expectancies.

In Section II existing work regarding the DAC, the prototype evaluation and other ICT-systems for EVs will be outlined briefly. A more detailed picture of the problem, the purpose of the DAC, and its main functionality will be given in Section III. Subsequently, the research design to improve the DAC in an iterative procedure and to assess the users' expectations will be outlined. It consists of three primary qualitative and quantitative surveys: In a first step, seven drivers were interviewed to get insights into their daily routines and attitudes towards supporting technology. This step is described in Section IV. The subsequent Section V shows how these findings were used to build the prototype. Later, 43 participants tested two different DAC prototypes and evaluated them with a focus on usability (Section VI). The third part of the evaluation includes the development of the functional demonstrator and is accompanied by a simulator-based test with participants from logistic companies and is described in Section VII.

[1] This paper is an extended version of a contribution to the international conference on advances in computer-human interactions (ACHI) 2016 in Venice, Italy [1].

II. State of the Art

Previous work on methods for software design shows a broad range of techniques that can be applied in different development stages. Cognitive walkthroughs, heuristic evaluation, formal usability inspections [6] offer interesting and valuable insights into a development process. More theoretical work focusses on the users' needs and expectancies as relevant factors for technology acceptance. Factors that influence the use of a socio-technical system cover the perceived usefulness, the attitude towards using a technology, and others [7], [8]. Other works in the field of DACs or EVs point out important factors that are relevant in the given context [9], but focus too much on the economic decisions of private households and cannot be adapted entirely to our project. Unfortunately, knowledge about important factors while using the DAC in a commercial context in EVs is rare. When it comes to a long-term research project in a field, where user acceptance is rather unknown, a flexible methodology that provides different forms of knowledge in various project stages is needed. Therefore, methods from social sciences were used. A qualitative research part is used to gather knowledge [10], and quantitative research helps to evaluate existing knowledge and design within a broader range of participants [11].

Apart from the very project, different projects investigate multiple aspects of the emerging technology of EVs and are funded within the German Information and Communication Technologies for Electric Mobility II (ICT EM II) program. The focus of ICT EM II is on new concepts for intelligent technology in EVs (Smart Car), combined with power supply (Smart Grid) and ideas for mobility (Smart Traffic) [12]. Projects like sMobility, iZEUS, Adaptive City Mobility (ACM), eTelematik and E-Wald focus on EV use in different kind of scenarios. However, all of them use ICT-systems to support different kind of EV-users. These projects indicate the broad range of driver assistance systems and mobile clients, as well as the need to evaluate them.

In a complex socio-technical system where EVs are used within different kinds of scenarios and the driver needs to cope with additional information (such as range, battery status, etc.) to fulfil his primary task, it is essential to reduce stress and uncertainty resulting from these important additional parameters. The used DAC has to fit the drivers needs, which have to be assessed thoroughly in each project.

III. The Driver Assistance Client

In the context of urban logistics, the driver has to cope with a lot of information, which often comes along with stress and the insecurity about the actual range of an EV. Since the range depends on a lot of parameters (e.g., battery capacity, driving speed, weather conditions, weight, etc.), the consideration of all those influencing parameters would be a complex process while driving. To reduce stress and eliminate insecurity, the DAC was developed. Basically, it works as a navigation system, providing optimised routes for EV, considering different range-affecting parameters of the vehicle while focussing on the planned tour. At the start of a tour, the driver can retrieve the tour on the DAC, which is already optimised and considers all parameters for the EV he is using. During the tour, the driver will be navigated to each point, gets information on possible changes to the tour, and all relevant information (e.g., traffic and weather conditions). As a result of this, the driver is relieved from thoughts about the range of the vehicle. Because the tour is always optimised and adapted to changes, the driver will be able to perform his tour and drive back carefree to the starting point.

Since the DAC should assist the driver while driving and reduce the added complexity, it needs to be easy-to-use in a vehicle. To find an optimal way to support the driver we elaborated an approach for the realisation of the DAC, wherein each iteration the acceptance and usability have been evaluated. The findings were used to improve further versions of the DAC.

IV. The Interview

In theoretical discourses on technology use, EV and driver assistance systems, different factors that influence the attitude, expectations, and acceptability towards these technologies in general public, are described [7, p. 188] [8, p. 447]. Beside these common factors, there may be particular ones among employees in logistics who use EV, which result from their specific situation (e.g., the employer-employee relationship leads to an involuntary use of the system). In the first place, the professional drivers need to perform their work task without unwanted disruptions by technological peculiarities and EV-specific uncertainties. To overcome the theoretical debate on barriers and drivers of technology acceptance, empirical evidence was gathered in qualitative interviews. Seven drivers from different companies were interviewed, using a semi-structured guide that was developed in advance. The interviewees were asked about their common work tasks, their attitude towards new technologies in general and EVs in detail, their expectations towards a DAC, some demographic items, and their employment biography. A content analysis of the interviews was conducted, and the deductive-inductive creation of categories [13] shed light on possible acceptance factors and requirements regarding a DAC in EV-based urban logistics. In theoretical debates, the general acceptance factors are described as perceived usefulness, perceived ease of use, the attitude towards using a technology [7, p. 188], and some models include the behavioural intention to use the system as well. These factors are influenced by moderators such as subjective norms, experience, the image of technology, job relevance, output quality, or the voluntariness of use [8, p. 447]. We found empiric evidence in the interviews regarding these items. Using the computer-assisted qualitative data analysis software f4analyse [14], we found out that the drivers tend to prefer a passive system. The system should give them useful information on important events during their tour, while not forcing them to act in a single, specified way. Other hints pointed in the direction of up-to-date maps, estimation and inclusion of time and range restrictions, the ease of use of and favoured support while implementing the system. These important factors for technology users were considered while developing the first versions of the DAC.

V. Building the Prototype

Taking into account the requirements that were identified in the interviews, as well as previous research, a first horizontal prototype was developed. Horizontal means in this case that the prototype has no real functionality, and was designed as a draft for the evaluation of the user interface. Figure 1 shows the tour overview and Figure 2 shows the information

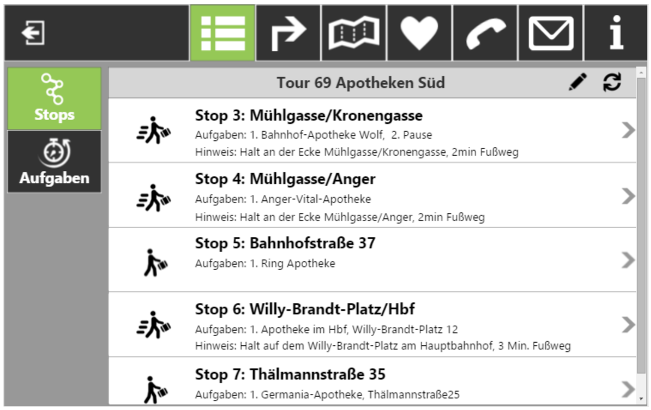

Figure 1. Tour overview of Prototype 1

Figure 3. Tour overview of Prototype 2

overview of the prototype. Both figures offer an impression of the main design. The main menu has been arranged on the top to allow switching directly between the main views such as tour information, navigation, map, vehicle status, direct call, messages and common information. To allow the navigation through different information, the submenu is arranged on the left side in each view. Since the DAC should be used on a mobile device with touch screen, big buttons were used, enriched with understandable and clear icons. After login the user directly views the tour overview with all relevant information on stops and clients. While driving, the user will mainly use the navigation view, which represents the route guidance.

During the development of the first prototype, some details of the design were questioned. So, a second prototype was build, which offers the same basic functionality, but has a slightly different user interface (UI) regarding the views. Figure 3 shows the tour overview for the second prototype. The main menu is also situated on the top of the screen and the submenu also on the left side, whereas the view of the content is divided into two parts, the item list and the content of the selected item. In Prototype 1, the list disappears when an item is selected, in Prototype 2 the item list remains visual, so the user can always see which item is currently selected.

Another difference compared to Prototype 1 is the overview of the main menu shown in Figure 4, which shows up directly after login. This UI provides an overview of all available functionalities. Creating two prototypes allowed to evaluate more options and the advantages and disadvantages from slightly different views. The evaluation itself and the results are described in the next section.

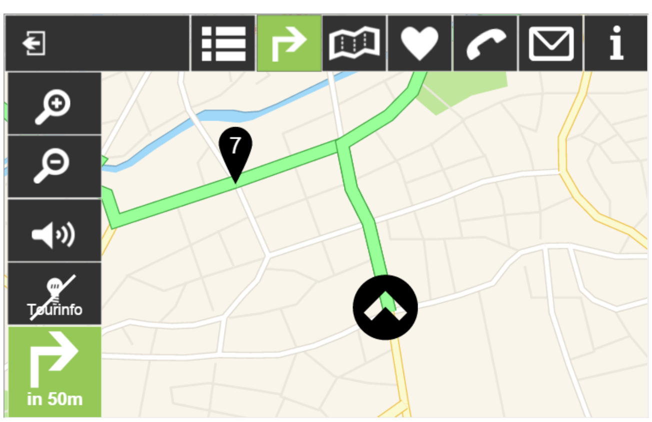

Figure 2. Navigation view of Prototype 1

VI. Prototype Evaluation

After developing the first two DAC-prototypes, possible users were asked for feedback in an online survey, targeting potential difficulties that may appear while using EVs in logistics. Before the users performed some basic tasks using the two prototypes, they were asked about different aspects of usability, using a standardised questionnaire focussing on the EN ISO 9241-110 norm [15], which was slightly adapted to the research context. For questions regarding the functions of the DAC, perceived ease of use, and intuitiveness, the users were asked to rank the particular characteristics of the prototypes on an ordinal 7-step-scale and to add qualitative information in free-text fields. Due to limitations in availability of interview partners at the partner companies who took part in the research project (and the resulting inefficiency to carry out the study on-site), an online questionnaire was developed using LimeSurvey [16], and an additional device with the DAC prototypes was brought to the partner companies. In each company, a contact person was instructed and responsible for conducting the evaluation. The access to the questionnaire was restricted by a 6-digit access code, which was handed out to the interviewees by the contact person in an envelope with some further instructions on the evaluation procedure. While the code itself was in a non-personalized envelope, it was possible to track the respondents' company and the order in which both prototypes were evaluated. The evaluation order was randomised based on the access code, which also made it possible to match the answers to the proper prototype. With this step, distortions as a result of answer patterns were prevented, and this procedure offered a high level of depersonalization. The online questionnaire was accessible for a period of 14 weeks, and the users were able to participate independently, at their individual best point in time. When participating, the users opened the envelope, accessed the online questionnaire and answered some fundamental questions before the first prototype was shown on the second screen. After performing some tasks, the users were asked to answer questions and rate the usability of the prototype,

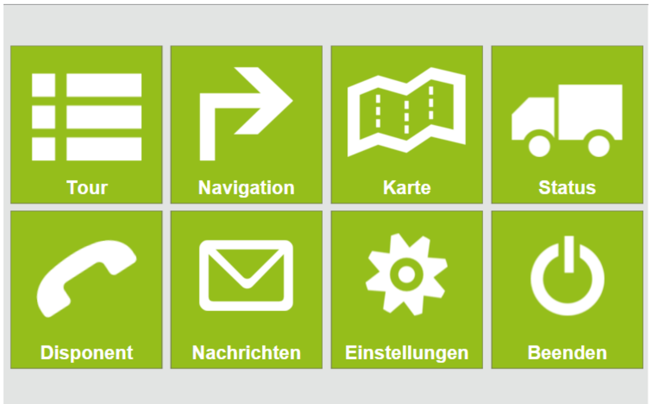

Figure 4. Main menu of Prototype 2

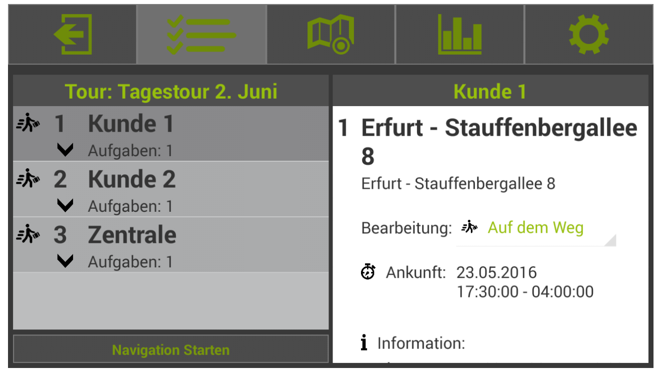

Figure 5. Tour overview of the demonstrator

before the same procedure started for the second prototype. The questionnaire concluded with free-text fields for ideas of improvement and some demographic questions.

With this approach, standardised and comparative information, as well as qualitative insights into the perceived usability of the two evaluated prototypes were gathered from 45 users. While two answers were excluded from the SPSS analysis due to reasonable doubt of sufficiency (e.g., when the evaluation of DAC was carried out in just a few seconds), the remaining 43 cases gave us some interesting insights on the usability of the evaluated prototypes.

First we examined the data and searched for feasible answer patterns between the first and second part of the questionnaire. It might be possible that the first evaluated mockup is rated below the second one in general (e.g., because of learning effects). Table I summarises the result of a sign test, addressing this question. The hypothesis is that the answers to the first and second part of our survey may differentiate simply due to the order of the questions. However, the null hypothesis (that the answers do not differentiate between the first and second block of questions) cannot be rejected in most cases. Regarding Table I, only the answers to question 13 tend to differentiate between the first and second part of the survey. This specific question used a double negative within its statement and the remarks in the free-text fields suggest that this confused at least some participants. As a consequence we decided to drop this question.

TABLE I. The result of the sign-test is used to check possible pattern of answers regarding the order of our evaluated mockups.

Statements (comparison of similar answers within the first and second part of this survey)	Exact sig. (2-sided)
1) The software offer required functionalities to handle tasks efficiently.	,115
2) The software is easy to use.	,388
3) The software facilitates a simple orientation through a uniform design.	,607
4) The used icons / terms reflect the underlying functionality.	,115
5) The size of the used buttons is appropriate.	,227
6) The size of the used icons is appropriate.	1,000
7) The size of the used fonts is appropriate.	,286
8) The software has a uniform concept for different kinds of interactions.	,143
9) The software requires little time to learn.	,344
10) The Software is easy to understand without any external support or user manual.	1,000
11) The software allows an easy switching between menus or masks.	,359
12) The software provides an excellent overview of their feature set.	,824
13) The software does not miss to inform about whether an entry was successful or not.	,070

In Table II, the median values to the closed statements are compared. Medians are used because of our input values, which can not be interpreted as a linear value due to the ordinal 7-step-scale. Regarding Prototype 1 and 2, the median values vary slightly only. The result tends to show a median around 4 to 6, while 4 is interpreted as a neutral rating and 5 to 6 as a positive rating. However, the used buttons within the prototypes were evaluated differently. The answers from the free-text fields complement our analysis.

As a conclusion we can summarize that in general, none of the two prototypes was evaluated better than the other. According to our analysis, Prototype 1 showed better results regarding the usability, while Prototype 2 achieved better results in clearness of design and intuitiveness. Based on these results, a set of adaptations was elaborated. Basically, it combines the positive characteristics of both prototypes. Finally, these adaptations were used to build a functional demonstrator of the DAC, which is described in the next section.

VII. The Functional Demonstrator and Evaluation

The most important difference regarding the prototypes and the demonstrator is that the latter is fully functional. Compared to the indicated functionality of the prototypes, the demonstrator has been reduced, based on the results of the evaluation. The remaining main functionality covers the tour overview, turn by turn navigation, status overview and settings. Figure 5 shows the tour overview and on the upper border the main menu. The submenu has been removed completely, so that the available space could be used in a better way. Also, the navigation view has been improved by removing unimportant buttons, such as the zoom in and out buttons (see Figure 6). To save space and reduce complexity, the vehicle status and common information (e.g., weather, traffic, etc.) have been merged into the status overview, and the direct call and messages views have been removed.

After two iterations, the DAC has been implemented as a fully functional demonstrator based on the recommendations of

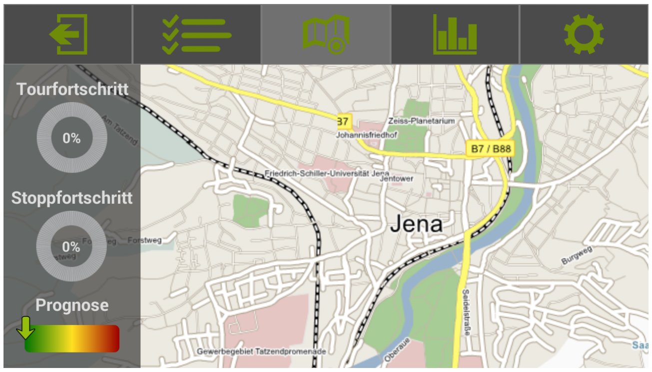

Figure 6. Navigation view of the demonstrator

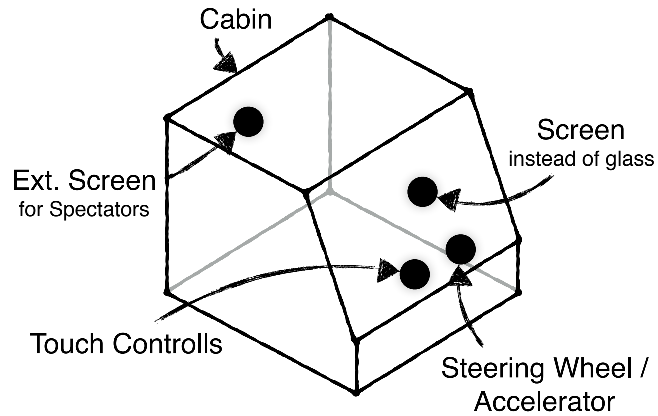

Figure 7. The Functional Demonstrator.

the participants during the evaluation. To ensure a high quality and a high usefulness, another iteration step concluded the project. In order to get further information on usability, the driver should use the DAC during his normal working day. To collect more data on possible insufficiencies, one final evaluation was carried out. This one focussed on drivers without particular EV-experience and was planned as a quantitative questionnaire.

Due to the fact that only a few drivers at the partner companies were able to participate while actually using EVs and the DAC, the significance of the results is restricted as a consequence. To overcome this problem, the demonstrator was evaluated by a higher number of professional drivers in Eltrilo [17], a simulator that was developed during the SCL project and is capable of simulating a real-world environment based on map data. Specific scenarios (e.g., transportation from a hub into town with multiple stops) can be simulated and be part of the evaluation.

Figure 7 presents the Eltrilo cabin schema. In front of the driver, a flat screen is the new virtual glass windshield in this setup. Besides the steering wheel, there are two additional small screens which form the cockpit. The cockpit touch screen allows switching cabin equipment (e.g., radio, air condition, lights) on or off. On the second screen, a navigation system and the cabin state (e.g., velocity is displayed). The driver assistance client is installed in the cockpit.

This simulator setup represents all components as used in real scenarios. The environment itself is based on real map data and generated through the procedural mechanism. This environment simulates specific scenarios like transportation from the hub into town with multiple stops. The simulation environment can create entirely terrain with height profiles, different types of roads, houses and road signs based on various kind of input data (e.g., ASTER GDEM V2 for height profiles and Open Street Map (OSM) data for road and house information).

Getting this into practice requires functional components as shown in Fig. 8. Primarily, some virtual simulation environment are necessary (1) and combined with real components, e.g., the DAC (2) and server (3). Realistic simulation behaviour and position mapping is possible. The componentes are linked to the simulation through a simulated telematic unit[2] (4) by using a data interface. Finally, this setup needs the car simulation (5) itself, some consumption simulation (6) which produces consumption based on user input when interaction with the simulated car and in-car electronics (7), e.g., speedometer and switches for hardware elements like light and air condition. A more detailed overview of components and architectural drafts

[2]Hardware element to gather telemetric data in real scenarios.

TABLE II. Table with median values according to closed questions within the mockup evaluation.

Statements	**Median Prototyp 1**	**Median Prototyp 2**
1) The software offer required functionalities to handle tasks efficiently.	4 (+/-)	4 (+/-)
2) The software is easy to use.	5 (+)	5 (+)
3) The software facilitates a simple orientation through a uniform design.	5 (+)	5 (+)
4) The used icons / terms reflect the underlying functionality.	5 (+)	5 (+)
5) The size of the used buttons is appropriate.	5 (+)	6 (++)
6) The size of the used icons is appropriate.	5 (+)	5 (+)
7) The size of the used fonts is appropriate.	4 (+/-)	4 (+/-)
8) The software has a uniform concept for different kinds of interactions.	5 (+)	5 (+)
9) The software requires little time to learn.	4 (+/-)	4 (+/-)
10) The Software is easy to understand without any external support or user manual.	4 (+/-)	4 (+/-)
11) The software allows an easy switching between menus or masks.	5 (+)	5 (+)
12) The software provides an excellent overview of their feature set.	5 (+)	5 (+)

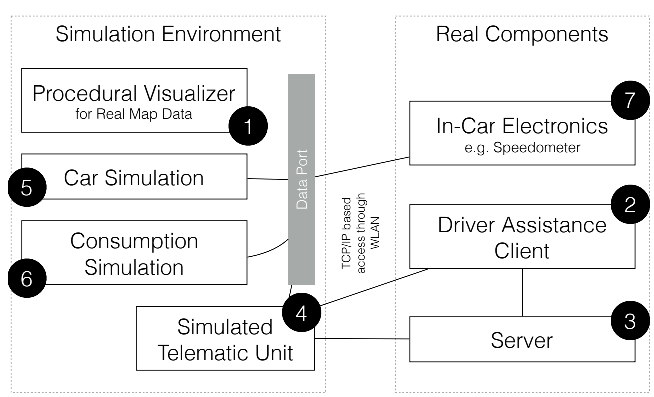

Figure 8. Components within the simulation environment.

TABLE III. Table with median, min and max values according to closed questions within the demonstrator evaluation.

Statement	Median	Min.	Max.
1) The software offer required functionalities to handle tasks efficiently.	5 (+)	1 (—)	7 (+++)
2) The software requires redundant input.	5 (+)	2 (–)	7 (+++)
3) The software provides enough information about input which is allowed and necessary.	5,5 (+)	1 (—)	6 (++)
4) The software provides situation based explanations, in the case of asking for, which is helpful.	5 (+)	1 (—)	7 (+++)
5) The software facilitates a simple orientation through a uniform design.	5 (+)	3 (-)	6 (++)
6) The software provides enough information about current running tasks.	5 (+)	2 (–)	7 (+++)
7) The software has a uniform concept for different kinds of interactions.	5 (+)	4 (+/-)	7 (+++)
8) The software requires little time to learn.	5,5 (+)	1 (—)	7 (+++)
9) The software requires that you have to remember a lot of details.	5 (+)	1 (—)	7 (+++)
10) The software is easy to understand without any external support or user manual.	5 (+)	1 (—)	7 (+++)
11) The software enforces an unnecessarily rigid compliance of processing steps.	4 (+/-)	2 (–)	5
12) The software allows an easy switching between menus or masks.	5 (+)	4 (+/-)	7 (+++)
13) The software enforces unnecessary interruptions of work.	5 (+)	1 (—)	7 (+++)
14) The software provides easy to understand error messages.	4 (+/-)	1 (—)	7 (+++)
15) The software requires at mistakes, on the whole, a slight correction effort.	4 (+/-)	1 (—)	5
16) The software provides accurate troubleshooting information.	4 (+/-)	1 (—)	5
17) The software can adapt well to my personal, individual nature of the work execution.	4,5 (+)	3 (-)	7 (+++)
18) The software is adaptable to varying tasks by myself, according to its possibilities.	5 (+)	4 (+/-)	7 (+++)

is published in [18] and [17].

In order to use Eltrilo, the DAC was installed into the simulator and connected to the live-system via a mobile network connection. In a first step, the participants received some detailed instructions on what they should do on their tour and how to use the DAC while performing their tasks in the simulator. During the simulation, some events affecting the tour were triggered, to simulate unpredictable changes of plans. In a second step, the participants were asked to answer a questionnaire on their experience in the demonstrator, as well regarding usability. The approach is similar and comparable to the investigation described in Section VI but bases on the improved demonstrator.

The simulator experiment was conducted in three different companies and ten drivers answered the questionnaire. Table III reflects the median, minimum and maximum values of the closed questions. The overall result tends to show a median around 4 to 5. Furthermore, the users were capable to use this system in combination with the DAC. All users were able to fulfil their virtual logistical task within a previously unknown scenario. Some users remark that the navigation system needs to react faster, has to give an improved overview on traffic information, and has to inform about exceptions and problems earlier. Regarding the functionality, some participants remarked that it is adequate, but has to become more stable. However, the last evaluation step doesn't replace the evaluation of experiences with the system in daily work routines. The results visualise a first trend and require more user feedback and experiences for further results.

VIII. Conclusion and Future Work

The development of a technological solution requires multiple iteration steps, a fact that is crucial for the evaluation and that is considered in the presented research design: opening up for qualitative information in the beginning of the project, where knowledge is limited and uncertainty about important acceptance factors is high, before focussing on the gathered knowledge and comparable evaluation questions with regard to existing norms and standards, is one way to assess technology development and to gain valuable information on user expectancy and experience. Due to the agile project management, the technology evaluation has to be open at any point in time for new information and changes, and needs to combine appropriate qualitative and quantitative research methods. This helps to achieve the best possible results, which can be implemented in further technology development.

This approach was used in the SCL project consequently. The first interview showed important aspects in the drivers' daily work routines that had to be considered while developing the DAC. The drivers prefer a passive system that gives hints and relevant, up-to-date information. The prototype evaluation revealed the positive aspects of two slightly different mockups that were implemented in the functional demonstrator. Two iterations resulted in a fully functional prototype of the DAC, which is broadly accepted by possible users. The third iteration step was done using a complex simulator environment, which used real map data and consumption simulations in combination with the other components used in SCL. The evaluation with ten participants showed that this system helps to fulfill the main task of the users in general and to reduce complexity. However, simulator stability has to be improved. In another step, feedback from the experiences while using the system in EVs in daily routines might complement the findings of this evaluation that accompanied the development of the SCL system.

Finally, these results will help developers while creating DACs in the context of EVs. As a next step, the evaluation can be carried out by a higher number of participants from different contexts (e.g., private users as well) to find additional use cases for the developed technological system. Additionally, it is required to expand this evaluation within a final study to get experimental data with working drivers. From a methodological perspective, a systematical analysis of methods for the evaluation of user expectancies can help to learn from different disciplines (e.g., computer sciences, social sciences) and to optimise the way, socio-technical systems are created and adapted to the users' needs.

Acknowledgements

We would like to thank all members of the SCL research team here at FSU Jena – there are too many to name them all in person. We would also like to extend our gratitude to our partners within the research consortium, end users, as well as research institutions and industrial developers. This project is supported by the German Federal Ministry for Economic Affairs and Energy in the IKT-II für Elektromobilität program under grant 01ME121(-33).

References

[1] C. Stolcis, J. Buchholz, and V. Schau, "Evaluation of a driver assistant client in the context of urban logistics," in ACHI 2016: The Ninth International Conference on Advances in Computer-Human Interactions,

A. L. Culén, L. Miller, I. Giannopulu, and B. Gersbeck-Schierholz, Eds. Venice, Italy: IARIA XPS Press, April 2016, pp. 235–239.

[2] European Commission, A roadmap for completing the single market for parcel delivery. Brussels: European Commission, 2013.

[3] K. Young, W. Caisheng, L. Y. Wang, and K. Strunz, Electric Vehicle Battery Technologies, 1st ed. New York: Springer Science+Business Media, 2015.

[4] Nationale Platform Elektromobilität, Ladeinfrastruktur für Elektrofahrzeuge in Deutschland. Statusbericht und Handlungsempfehlung 2015 (Recharging Infrastructure for Electric Vehicles in Germany. Status Report and Recommended Action. Nationale Platform Elektromobilität, 2015.

[5] Bundesministerium für Wirtschaft und Energie, "IKT für Elektromobilität (ICT for Electromobility) II," Internet, http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/Technologie-und-Innovation/ikt-elektromobilitaet,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf, 2016.03.16, 2013.

[6] J. Nielsen, "Usability inspection methods," in Conference Companion on Human Factors in Computing Systems, ser. CHI '94. New York, NY, USA: ACM, 1994, pp. 413–414. [Online]. Available: http://doi.acm.org/10.1145/259963.260531

[7] V. Venkatesh and F. D. Davis, "A theoretical extension of the technology acceptance model: Four longitudinal field studies," Management Science, vol. 46, no. 2, 2000, pp. 186–204.

[8] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," MIS Quarterly, vol. 27, no. 3, 2003, pp. 425–478.

[9] S. Arndt, Evaluierung der Akzeptanz von Fahrerassistenzsystemen. Modell zum Kaufverhalten von Endkunden. VS, Verl. für Sozialwissenschaften, 2011.

[10] J. Gläser and G. Laudel, Experteninterviews und qualitative Inhaltsanalyse. Wiesbaden: VS Verlag für Sozialwissenschaften, 2009.

[11] R. Schnell, P. B. Hill, and E. Esser, Methoden der empirischen Sozialforschung. München [u.a.]: Oldenbourg, 2008.

[12] Bundesregierung Deutschland, "IKT für Elektromobilität II," Internet, http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/Technologie-und-Innovation/ikt-elektromobilitaet,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf, visited 2015-10-21, Mai 2013.

[13] U. Kuckartz, Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung (Qualitative Content Analysis. Methods, Practice, Computer-assistance). Weilheim und Basel: Beltz Juventa, 2012.

[14] Dr. dresing and Pehl GmbH, f4analyse 1.0.0-rc4- Computer Assisted Qualitative Data Analysis Software (CAQDAS), Internet, https://www.audiotranskription.de/f4-analyse, 2016.03.16, Marburg.

[15] J. Prümper, "Isonorm 9241/110-s: Evaluation of software based upon international standard iso 9241, part 110 - manuscript questionnaire," Internet, http://people.f3.htw-berlin.de/Professoren/Pruemper/instrumente/ISONORM_9241_110-S_2010.pdf, 2016.03.16, Berlin, 2010.

[16] C. Schmitz and LimeSurvey Core Development Team, "Limesurvey - free open source survey tool," Internet, https://www.limesurvey.org/en/, 2016.03.16.

[17] V. Schau, S. Apel, K. Gebhardt, J. Kretzschmar, M. Mauch, and C. Stolcis, "Evaluating ict-systems for electric vehicles within simulated environments," in Proceedings for the 19th Gulf Engineering Forum Smart Solutions, Kuwait City, in press.

[18] V. Schau, S. Apel, K. Gebhardt, J. Kretzschmar, C. Stolcis, M. Mauch, and J. Buchholz, "Intelligent infrastructure for last-mile and short-distance freight transportation with electric vehicles in the domain of smart city logistic," in Proceedings of the International Conference on Vehicle Technology and Intelligent Transport Systems, April 2016, pp. 149–159.