Service and Usability Engineering Based Approach for Flexible Mobility

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Abstract. Changing general conditions, e.g. demographic change, rural flight and diminishing funds, and new expectations from mass transit users are compelling transportation companies, especially mass transit authorities, to develop new and flexible mobility services. This paper describes an approach that combines methods of service and usability engineering and also presents the initial results of analyses and specifications. The findings reveal the different views of companies and users and serve to identify the challenges of and opportunities for new flexible and user-centered mobility services.

Keywords: Service engineering · Usability engineering · Mass transit · Public transportation

1 Introduction

Public transportation is tremendously important: People select their places of residence based on the availability of public transportation. Many people's daily routines (e.g. commuters) are significantly dictated by mass transit services. Public transportation also provides socially disadvantaged individuals opportunities to partake in social life. What is more, mass transit presents numerous opportunities over private motorized transportation: Demands for transportation are satisfied cleanly and energy efficiently, traffic is reduced in the public sphere, and customers can use the time in transit to relax or work [1].

German mass transit companies, however, will have to face key challenges in the coming years. Urban flight, continuous decline in the number of school students, and pressure to continually improve profitability are but three examples [2].

While demand for transportation is increasing or will at least remain static in cities, it will continue to decline in rural areas. Public transportation, especially the German mass transit system in its present form with inflexible routes and scheduled timetables, will no longer be financially viable in rural areas in the medium and long term [3]. Moreover, using scheduled means of transportation to meet individual demands for transportation among the populace will be extremely difficult [4]. Disruptive innovations will be

M. Kurosu (Ed.): HCI 2016, Part III, LNCS 9733, pp. 259–268, 2016.
DOI: 10.1007/978-3-319-39513-5_24

essential to the continued provision of high quality transportation services to the rural population [3]. This will require technological innovations such as autonomous driving and especially service innovations.

This paper describes how methods of service engineering [5] and usability engineering [6] can be combined and refined to systematically develop new transportation services for rural areas. The aim is to develop services that satisfy the rural population's transportation needs resource efficiently and provide transportation users easy and flexible access to transportation and information services by designing them user-centered.

The analyses cover the German state of Saxony-Anhalt. This state with only two major cities (Magdeburg and Halle) is particularly being affected by demographic change and migration within Germany. The state lost close to 19 % of its population from 1990 to 2010. Approximately 1.74 million of the state's 2.28 million residents live in rural regions. Its population density of 112 residents per square kilometer, which is comparatively low for Germany, poses major challenges to the German mass transit system [7].

2 Method

2.1 General Approach

The service engineering process model developed by Bullinger und Schreiner [8] has been combined with Mayhew's usability engineering life cycle concept [9] to form an integrated conceptual framework in order to achieve the stated goal of resource efficient, flexible and user-friendly transportation. This entailed cutting the six phases of service engineering (start, analysis, specification, preparation, testing and implementation) put forth by Bullinger and Schreiner down to four phases in order to render the approach highly concurrent. Table 1 presents the approach and the methods used.

The first phase of the integrated conceptual framework covers the development and evaluation of ideas for new transportation services. This entails ascertaining the con-text of use with the specific attributes and demands of transportation users. The second phase is the specification of concrete partial services. Concrete specifications are derived from users' demands and factored into the design of service processes. Parallel to this, mock-ups are created, screen design standards are defined for specific products, and the user interface is developed. The second phase also includes combining the partial services developed in an integrated unified transportation service (system pooling). The third phase covers the testing of the transportation services developed. To this end, the resources required to provide a service (e.g. vehicles, communications infrastructure, control center) are provided, staff is trained appropriately, test users are selected, and the test setting is defined. Then, the test results are analyzed to identify other actions that will improve the service and these are implemented systematically. The fourth and final phase is the implementation and successive improvement of the integrated unified service on the market.

Table 1. Combined methods of service and usability engineering [6, 8–10]

Service Engineering	Set of Methods	Usability Engineering
Start and analysis phase Goal: Create ideas, analyze requirements and assess ideas	Analyze statistics	**Requirements analysis** Goal: Understand and specify the context of use
	Modularize of transportation services	
	Conduct interviews and surveys	
	From focus groups	
	Perform a means-ends analysis	
Design phase Goal: Define detailed and general specifications	Define services and specifications	**Design, testing and Development** Goal: Develop and evaluate design solutions
	Design transportation and information systems	
	Develop user interfaces	
	Develop service systems	
Evaluation phase Goal: Test specifications	Perform tests and evaluations with experts and users	
Implementation phase Goal: Implement solution	Obtain user feedback	**Installation** Goal: Implement solution

2.2 Analysis Phase

This paper concentrates on the first phase of the aforementioned conceptual framework. The goal is to identify starting points for the development and design of new transportation services for rural areas. The methods presented in Table 1 are used.

Secondary Analysis. This analysis is intended to identify typical types of customer structures in the region analyzed. The users are stereotypical in terms of their transportation demands and represent a large number of users in the region analyzed. The analysis of the data sets "Transportation in Germany" [11] and "Transportation in Cities" [12] is used to analyze the population's use of transportation in the region analyzed on the basis of key household and transportation indicators, thus establishing the basis for developing individual and flexible transportation services.

Interviews With Experts. Building upon the quantitative findings on types of customer structures as well as a detailed analysis of literature on the planning and operation of mass transit systems (including [2, 13, 14]), service productivity (including [15–17]), service engineering (including [10, 18–20]) and electric vehicle networks (including [21–23]), interviews with experts are intended to generate qualitative data. The partially standard interviews are conducted with representatives of mass transit companies, mass transit authorities and mass transit networks in order to integrate every relevant stakeholder. The results along with the experts' assessments of the aforementioned topics will also establish the basis for the subsequent online surveys of mass transit companies and customers.

Online Survey of German Mass Transit Companies. The written survey (modeled after [24]) is used to ascertain, among other things, whether companies have already entered collaborative partnerships with other transportation service providers (e.g. car sharing, bike sharing, rideshare agencies), the extent to which electric vehicles are being used, and what forms of flexible services (e.g. dial-a-bus, dial-a-taxi) are al-ready in use now. In addition, the mass transit companies' assessment of their own efficiency and effectiveness is examined. Ultimately, it will be possible to define the current state of responsiveness and the use of innovative transportation services and identify best practices.

Online Survey of Mass Transit Users. The survey of German mass transit system users focuses on the region analyzed and scrutinizes the findings of the secondary analysis from the perspective of transportation users. Among other things, it collects key transportation indicators on different purposes of travel as well as the demands and expectations on current and future transportation concepts. To this end, the respondents are given an opportunity to evaluate existing German mass transit system services on the basis of various criteria such as access and accessibility. The findings enter into the refinement of types of customer structures and the development of service concepts on the level of idea generation of and business model creation.

Focus Groups. Focus groups are intended to help further refine the types of customer structures and facilitate the development of new flexible transportation concepts. In addition, the related factors for the selection of a means of transportation will be identified and weighted for different transportation services. The focus groups reproduce the types of customer structures relevant to the region analyzed and specify different transportation scenarios and purposes of travel, e.g. tourism, commuter traffic and occasional and daily travel.

3 Results

The overall results of the first phase reveal particularly high potentials for responsiveness of transportation services in the region analyzed. The secondary analysis revealed the region's failure to exploit its potential for regular German mass transit system customers when compared with the German average. What is more, a large number of routes traveled are shorter than 1 km (0.62 mile). The number of pedestrians and cyclists is significantly elevated. Commuter traffic also harbors potential that transportation service responsiveness can tap.

3.1 Secondary Analysis

The first step of the secondary analysis entailed identifying five types of households in Saxony-Anhalt. They are classified on the basis of the two criteria of car availability and household size (see Table 2). In the second step, these were refined with typical features of transportation, e.g. distance to next mass transit access point or use of transportation services for different routes.

Table 2. Household types in Saxony-Anhalt [11]

	Household size			
		One- person household	Multi-person house-hold without children	Multi-person household with children
Car avability	No car	Retiree over 65, no driver's license		
	One care	Full-time employee, 45-64, driver's license, perhaps a motorcycle	Retired married couple, over 65, both with driver's licenses	
	Two cars		Married couple, part/full time employees, 45-65, both with driver's licenses	Married couple with school age children, part/full time employees, 25-44, both with driver's licenses

The first type of customer structure is a retiree living alone. She has neither a driver's license nor a car and is over sixty-five. She takes trips primarily in the vicinity. Another type of customer structure with the attribute "one-person household" is a working man aged forty-five to sixty-five. A full-time employee, he has a driver's license and a car, and uses them for his daily commute to work.

3.2 Interviews with Experts

Achieving the stated goal of transportation service responsiveness requires factoring in both the customer and the corporate perspective. The significant findings from the two to three-hour interviews conducted with seven experts in the realm of customers on four days are:

- The majority of customers of the companies surveyed are captive users, i.e. customers, primarily older individuals and school students, who have neither a driver's license nor a car and are therefore reliant on mass transit. They primarily use mass transit to travel to school or to medium and large urban areas.
- Typical customer demands include more individualized scheduling, even in off-peak hours, and the reduction of transfers. Universal accessibility of stops, vehicles and information systems are also wishes frequently expressed by customers.
- In particular, the frequency and periods of use, the time spent in transit, the pricing system and perceived inferior flexibility to one's own car were identified as barriers to use.

The following qualitative findings were obtained from the corporate perspective, i.e. the perspective of the mass transit companies, networks and authorities:

- Classic approaches to mass transit responsiveness, e.g. on-demand taxi, dial-a-bus and scheduled taxi, are already in use and will be used more in the future.
- The companies surveyed in the region analyzed do not collaborate with car or bike sharing providers or other alternative transportation providers. Reasons given are the lack of availability of suitable services, the unprofitability of such collaborative partnerships, and fears of cannibalization and crowding out.
- The respondents are fundamentally open-minded about electric vehicles but see numerous obstacles in the requisite charging infrastructure, service garage availability and profitability, which argue the use of electric vehicles in mass transit.
- The respondents have widely varying understandings of efficiency and effective-ness. The target variables hardly have any relevance for daily work. Key indicators that operationalize target variables are either not measured at all or measured on the basis of individual initiatives. The findings are only evaluated and discussed sporadically, if at all.

3.3 Online Survey of German Mass Transit Companies

The findings on mass transit responsiveness, transportation service efficiency and effectiveness and the use of electric vehicles obtained from the survey of experts constitute the foundation for the design of a nationwide survey of mass transit companies. The questionnaire prepared for this contains thirty-two question batteries arranged in six domains:

- Company information, services offered and infrastructure,
- Collaboration with other transportation providers,
- Productivity of the services offered,
- Alternative transportation services, e.g. flexible forms of use and sharing,
- Use of electric vehicles in transportation services, and
- Information on respondents, e.g. position and function in the company.

Since the survey had just started at the time this paper was being written, the response rate is very manageable (N = 20) so far. The portion of the results presented below are therefore preliminary findings intended to illustrate the potential responses when the response rate is commensurate. Table 3 presents select results on the range of services and the vehicles used.

The self-assessment of productivity delivered surprising results. 54 % of the respondents rate the productivity of their own transportation services as low or very low. The respondents are similarly critical of their transportation services' customer orientation. 50 % of the respondents do not concur at all with the statement, "The customer is always able to find information on current departure times, delays and connection (e.g. by smartphone)". Approximately 82 % of the respondents indicated that their companies already employ flexible forms of use. The form of services most frequently used by the respondents is the dial-a-bus in on-demand service [25].

Collaboration with transportation service providers is more advanced than the results of the survey of experts suggested. According to the survey results to date, approximately

Table 3. Select results from the survey of mass transit companies

Subject	Preliminary Results
Permit for regularly scheduled service	• Have a permit for regularly scheduled service: 63 % • Have applied for a permit for regularly scheduled service: 11 %
Types of vehicles used	• Two-axle standard bus: 81 % • Articulated bus: 44 % • Shuttle bus: 31 % • Three-axle standard bus: 19 %
Drive system of the of vehicles used	• Diesel: 63 % • Natural gas: 19 % • Hybrid: 19 % • Electric: 19 %

67 % of the respondents are already collaborating with both car and bike sharing providers. Approximately 87 % of the respondents indicated that they collaborate with taxi companies. 60 % of the respondents collaborate with intercity bus companies. The respondents tend to be restrained in their assessment of the suitability of alternative transportation services to enhance classic mass transit, however. The division of the profits was cited (by approximately 43 %) as the greatest obstacle to collaboration with (other) alternative transportation services. According to the respondents, the greatest potential provided by such collaboration is the related image boost (approximately 33 %).

3.4 Online Survey of Transportation Users and the Focus Groups

The preliminary results from the first focus groups and evaluation of the online survey reveal transportation users' perspective. The typical purposes of travel from the secondary analysis and the expectations already identified by the interviews with experts have been validated.

Moreover, transportation users' expectations of integrated services are growing and easy access and uncomplicated billing and payment as in now common in other sectors, e.g. mail order, is especially important. Concepts with electronic transportation cards that facilitate access to different transportation services are favored. A tendency to view many alternative transportation services as events rather than as transportation options was extracted from the tourism transportation scenario. This aspect could prove to be important for acceptance among transportation users when innovative transportation services are introduced.

4 Discussion

The challenges in the region analyzed and the goal of designing customer-centered flexible transportation services for rural areas necessitate integrating approaches and methods based on service and usability engineering. The development of the conceptual framework in the first phase demonstrated that combining both disciplines is not only theoretically possible but also feasible and practicable. The methods selected represent just a few of the options that will have to be expanded expediently and validated further.

The findings and results obtained by applying the proposed methods already demonstrate, however, that they are essential to the design of new transportation services. The conceptual framework and the methods used additionally make it possible to ascertain the population's demands for responsiveness and interface design thoroughly and to integrate them in development. The approach's sustainable impact will have to be demonstrated in the future by completing every phase and, in particular, by implementing the transportation services. What is more, the approach will have to be discussed further.

5 Conclusion

The integration of different perspectives constitutes a basis for the development of new transportation services. The complex milieu of different stakeholders on the level of transportation service providers and the diversified structure of transportation users will require comprehensive and detailed analysis of demands and basic conditions as well as a detailed analysis from the perspective of service already when development and design commence. The approach presented and the initial results of the phase of demand analysis have revealed the opportunities that arise from combining the approaches.

The next steps will entail further refining the approach and the results in the analysis phase, e.g. by using other methods. What is more, the second phase of the integrated conceptual framework has to be specified in more detail and verified in a real-world case study. Concrete scheduled services will be selected for the region analyzed and new integrated partial services will be developed by applying the methods presented in Table 1. In keeping with the results from the analysis phase, this will both be used to advance the networking of the different transportation providers and to gear user interfaces more toward transportation users' cognitive capabilities and skills and expectations.

Acknowledgements. Part of this work was funded by the German Federal Ministry of Education and Research (BMBF) grant number 01FE14033 and 01FE14034 as part of the project Move@ÖV.

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