Usage Phases in the Development of Product Systems Exemplified by a Route Recommendation Scheme for Cyclists

Sigmund Schimanski(✉)

University of Wuppertal, Wuppertal, Germany
schimanski@uni-wuppertal.de

Abstract. In the course of digitization, users increasingly desire navigation processes with individualized and flexible system solutions or human-machine-systems. This results primarily in early development stages with a vast complexity and growing requirements. For this reason, this paper is based on our self-developed perspective on usage phases in the context of navigation to create sustainable user interfaces with a reduced complexity. The usage phases include the differentiated subject matters of applying technical systems, which need to be considered when designing new system concepts. First of all we agreed on the most important indicators in the usage phases of product and system development in context of mobility, which we then examined in an e-vehicle survey, and modified for the next validation phase. In this phase, we used the example of cyclists to demonstrate the application of usage phases for the derivation of a route recommendation scheme. The results obtained will be presented in this paper.

Keywords: Usage centered design · Human factors engineering · Systems engineering · Product life cycle · Fuzzy front ends

1 Purpose Intention

The observation of the individual usage phases allows a holistic understanding of the application of technical systems in the complete cycle of use. This usage awareness leads developers to comprehensive and constructive approaches regarding requests, ideas and functions etc. for a holistic interaction approach between human and machine as well as a high time efficiency. After respective evaluations, the criteria catalogue is falsified in the usage context, and merged into a universal model. The resulting model is used in the early development stages of other products, systems, services etc. with a key focus on human-computer interaction [5].

2 Design/Methodology

The previously hypothesized usage model is the basis for our analysis. To construct this model, we initially looked at the product life cycle model, which is mainly used in commerce. Typical elements of this cycle are, for example, the extraction of raw

M. Kurosu (Ed.): HCI 2016, Part III, LNCS 9733, pp. 331–342, 2016.
DOI: 10.1007/978-3-319-39513-5_31

materials at the beginning and the disposal at the end. An intermediate element, which is most often included, is the consumption or use. This is (Fig. 1) where our model begins.

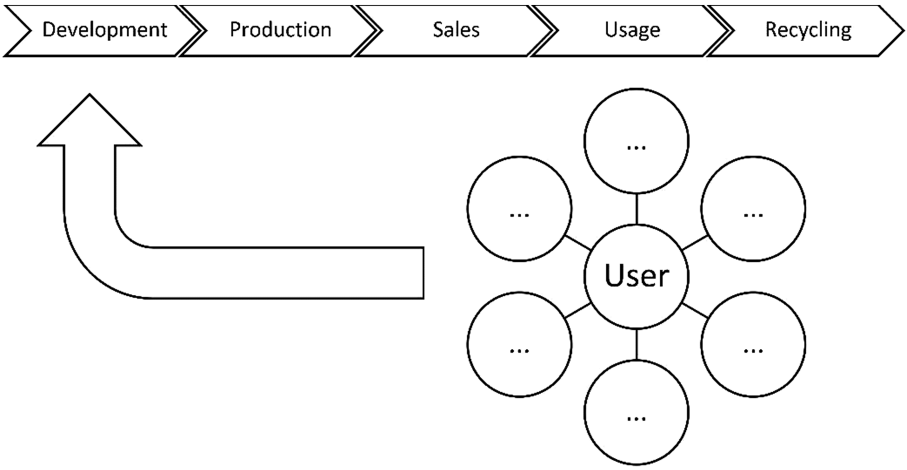

Fig. 1. Usage phase in product life cycle

Our concept, depicted in Fig. 2, is based on the user, who is also part of a system of influence.

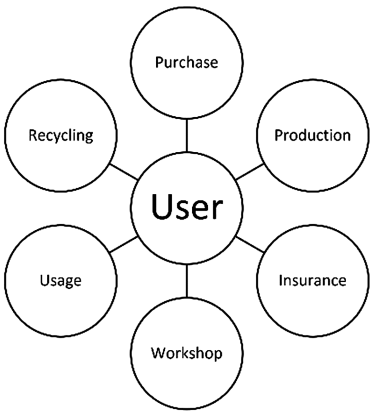

Fig. 2. First elements of the usage model

This system comprises various actors. They consist of different aspects of the product life defined by the interaction with the user. The user represents the consumer, making the user the center of the product system. His wishes, concerns, requirements and behavior are meant to enable the development of new, user-centered services. In this context, the main focus is the identification of beneficial potentials. This allows the

creation of innovative solutions in the further process that consequently increase the appeal of interactive products or services.

Crucial for the identification of beneficial potentials, possible innovations and personal ideas was the choice of interview technique.

To be able to implement the requirements of the interview, the only suitable choice was a freeform interview, i.e. a non-standardized or only partially standardized inquiry, which were held in person, orally and took place in a casual environment outside the laboratory. This form of interview technique poses nearly no comprehension problems, and prevent suggestiveness [6, 7].

The conducted interviews started with a neutral introduction of the whole issue of cycling and navigation, and more and more transitioned to a free narrative form, in contrast to standardized question-answer-dialogs between moderator and test person [2, 4]. The moderators explained the topic and the interview process at the beginning, and then gradually withdrew and let the users/experts express themselves freely about the overarching topic of "route optimization for cyclists".

2.1 Model Validation with an E-vehicle Survey

We designed questions for an e-vehicle survey based on e-vehicle owners these actors, aiming to either verify or falsify the assumed factors of influence. Additionally, we wanted to reveal further relevant aspects and the implicit knowledge of the users. For this, we included a variety of rather unspecific questions allowing the users to contribute personally relevant aspects (e.g. asking them about their wishes regarding the interconnection of electric mobility and living).

The final survey about electric mobility consisted of eleven different subject matters: general personal information, general vehicle details, purchase information, act of purchase, use, charging infrastructure, insurance, accidents, maintenance, exploitation and concluding comments. With the exceptions of "general personal information" at the beginning and "concluding comments" at the end, the survey chapters appeared in random order to prevent sequence effects.

The complete survey consisted of 16 open and 69 multiple-choice questions. The great number of open questions is a particular feature of the survey. The open questions give users sufficient space to answer in their own words. As there are no predefined answers, users can freely define length and content of their answer. The purpose of this form of inquiry was to ensure a comprehensive detection of all aspects important to users. The results allow us to extract relevant issues, and examine them closely. Additionally, new subject matters might emerge that other answer formats would not generate. Some questions were only asked if the user had picked a specific answer in the previous question. The intention of these open questions was to allow detailed explanations, and to provide more information about gaps and user wishes.

Some of the multiple-choice questions allowed users to pick more than one answer option. Aiming to provide all participants with a suitable answer, users could often choose the answer option "other", and specify their reply in a blank field. Other multiple-choice questions had rating scales with consistent extremes, if possible. They resembled

the school grading system, i.e. “one” representing a positive and “six” a negative answer for electric mobility.

The survey took an average of 30 to 60 min. Although some participants needed much less and others much more time for answering all questions.

We adjusted the user model after the evaluation of the e-vehicle survey. With the replies of the 213 participants, we generated new criteria that considered all relevant factors of influence, especially in the context of mobility. The detailed results will be shown in the chapter “research/practical Effects” (Fig. 3).

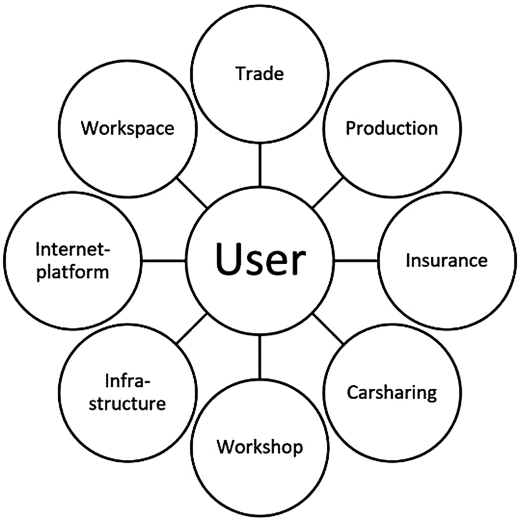

Fig. 3. Custom elements of the usage model

2.2 Usage Model Validation with an E-bike Survey

After the first validation loop, we modified and complemented the usage model and started the second attempt with the focus on a route recommendation scheme for cyclists. In order to identify possible indicators and beneficial potentials for the recommendation algorithm with examples of real use of route preferences in the context of cycling, our next step involved the conduction of expert interviews with daily cyclists, GPS examiners, spokesmen of professional associations, specialists for urban development, mobility and geo applications. In total, we conducted 35 interviews with 16 pedelec users, 7 cyclists, 10 Hardware specialists, 2 electric mobility experts, 2 sport and medicine experts, 2 PR experts, Those interviews only consisted of open questions about requirements, wishes and habits while using e-bikes/pedelecs with regards to usage phases, purchase information, purchase act, use, workplace, rent, charging (infrastructure), insurance, accidents, maintenance, exploitation, information platforms, and concluding comments. With the open, and ocassionally guideded, interview approach, we could especially identify implicit user knowledge, as will be discussed in the next chapter (results). For the evaluation, we detected relations between the statements and grouped

them into overarching topics. This resulted in separate using phases within the context of cycling mobility, which were applied to the further system development process. The developed partial concepts were integrated in an innovative route recommendation algorithm, which will be demonstrated briefly in the following (results).

3 Results

3.1 Results of the E-vehicle Survey

Workshops were generally criticized for their minimal offers. An additional request was that special towing services would take care of any completely discharged vehicle, and transport it home. Insurances were generally criticized for not offering sufficient information. Rates should be more transparent and pricier. Also missing is an appropriate way to compare the rates. Some users also wanted a special rate for electric mobiles that considers special attributes, such as batteries and charging technique, as well as a consistent charging rate. Car sharing was considered appropriate, and some users wanted this service to be offered in residential areas. Furthermore, it should be possible to rent private electric cars for days or hours. An enhancement of the subject of car sharing was the request for swarm cars, which can be used by everyone. Especially German manufactures were criticized for the amount and quality of their advertising. An improvement of this situation would be widespread, realistic and honest advertisement in general media. According to user opinion, manufacturers should put more effort in performance and range, and try to offer electric cars at a better price. Time and again the users wanted manufacturers and car dealers to establish central information centers for electric mobility, which should offer all of the important information, and — according to user opinion — counteract a complicated and extensive search for the important facts. But dealers were generally asked to offer diversified information to related topics, such as insurance and charging technology. The dealers should have better knowledge about electric mobility and be motivated to sell them. One user suggested, being the user of an electric vehicle himself, to act as a recruiter and consultant for new customers, i.e. working for the car dealer. An important and often mentioned aspect is the need for test drives. They should be offered proactively, preferably in form of test days or test weeks to convey an everyday concept of electric vehicles. Usual Internet platforms for selling vehicles should have own categories/sections for electric vehicles. This would catch the attention of normal users as well. As the Internet is already one of the most effective sources of information for electric mobility, this function should be enhanced. An especially relevant area is the working place. User asked for charging stations at work or near their working place. The furthermore expressed an interest in having electric company cars or being able to lease such a vehicle from their employer. Electric vehicles should also be used on-site. A major point of criticism was the still insufficient charging infrastructure. The users want more and extensive charging stations that are accessible at all times. Another important aspect is a uniform connector system, and a paying system that works without registration in advance. Everyone should be able to charge at any charging station. Many users mentioned that charging stations were often not working. This shouldn't be the case — but if a malfunction occurs, responsibilities should be clearly specified. A common user wish was an app that would allow

direct contact between charging station and vehicle. It could offer route recommendations according to charging points, access the status and other information of the charging station (connector type, payment method and charges, accessibility, current form etc.) Booking the charging station should be possible with the app.

A previously unexpected part of the system in which the user is active is legislation and therefore the government. The gaps and needs discussed here refer to other areas, that's why the government is not included as a separate player but can be regarded as an additional factor in the background. In addition to investing in a meaningful charging infrastructure, users especially wish for statutory regulation. For example, clear towing regulations for the illegal parking of combustion vehicles on charging stations. Accordingly, such parking lots should be indicated more clearly. According to user opinions, new car parks and rental houses should only get building permits if the construction plans include a charging station. The users also want companies from a certain size onward, or in case of an existing demand, to be obligated to offer charging stations. For this, another statutory regulation is needed that permits employers to legally sell electricity to their employers. Private citizens should also be able to sell their electricity to users of electric vehicles. Some users would like the legal opportunity to put up a charging station in a rental house or in a public space. Another request was an inexpensive system for transferable license plates. Some drivers supported benefits and privileges for electric vehicles, e.g. a reduction of vehicle taxation. Desires in the context of road transport were free parking, use of bus lanes and/or other advantages.

3.2 Impacts of the E-vehicle Survey on the Usage Model

First, the survey could confirm and support all previously assumed factors of influence of the usage model.

A complete section consisting of eleven questions concerned the charging **infrastructure**. This section represents the domain of the actual use in the usage model as the use of the vehicle is directly related to the given infrastructure. The frequency of replies as well as the answers themselves justifies the incorporation of the infrastructure into the usage model. For example, 89 % of the participants answered the open questions in the section "Within the context of electric mobility, what are your wishes concerning infrastructure?". The question regarding the necessity of a charging infrastructure yielded a mean value of 1.59 with an available continuum form 1 "very relevant" to 6 "not relevant".

Insurance is already an important aspect of the usage model as insurance is mandatory for vehicle owners. The question about further wishes/desires regarding insurances often generated emotional contributions, which emphasizes the importance of this subject matter to users of electric mobility.

The term **workshop** in the context of maintenance has been mentioned directly in two distinct questions in the survey, and is alluded to in the acquisition of accidents and repairs. 45 % of the users had to have their vehicle repaired; this makes workshops a relevant subject matter. On average the participants answered the question on how satisfied they are with the range of workshops only with 3.27, in a continuum from

1 “very satisfied” to 6 “very dissatisfied”. This shows, that this is a crucial topic with obvious gaps, and therefore needs to be integrated into the user model.

Production is not directly brought up in the survey, but the manufacturer is often mentioned by the participants in the disclosed questions “where do you see possibilities of improvements for information capacities?” and “were you satisfied with the information available to you. If so, why?”. As users see the manufacturer as their starting point with regards to purchase and further development, it verifies the role of the manufacturer in the user model.

Dealers are twice directly mentioned in the survey. For example, as an answer option for the question “where did you gather information before your purchase?” Almost half of the participants said that they got their information from a car dealer. We also asked for the number of dealer’s users visited and got an average result of two – due to the massive Internet use, this can be considered a high value. Moreover, different statements on the topic of car dealers have been made in the context of other open questions. Among them was the question for suggestions to improve the possibilities for gathering information. 39 answers held the car dealers accountable in this field. Good or bad dealers were named 24 times as the reason for the made judgments regarding the received information. Overall, this player is absolutely relevant for our user model.

The section workplace has been addressed with much disclosed questions in the survey (e.g. “which kind of networking do you desire/wish for regarding electro mobility and work?”). This question has been received very well and has been answered by over 78 % of the participants. Overall long and very detailed statements have been made. In the disclosed question “conclusive comments” the workplace has been mentioned as very important multiple times. Users wished a more detailed elaboration for the topic “workplace”. This is why the workplace was also incorporated into the user model.

Internet platforms have been mentioned in the survey as an option to the question, “what would be the most likely way on how you would proceed when reselling your electric vehicle?”. The option Internet platform has been chosen by 62 % of the participants. Additionally, we asked if users would order a vehicle via Internet, this question was positively answered by more than half of the participants. This shows the relevance of this topic with regards to electric vehicles. Some participants wished for advertisements and presence for sources of information in some of the disclosed questions. Users stated multiple times that the internet – bulletin boards in particular – yielded the most useful bits of information regarding electro mobility. Compliant over 80 % stated to have used the internet as a source of information before the purchase. Also the desire for an App regarding infrastructure has been made and can be seen as an indicator for the relevance of the internet. Therefore, the Internet is incorporated into the user model as a global factor.

Car sharing has not been mentioned directly in the survey. In open questions, such as “what kind of networking do you wish for in the context of electric mobility and living” or “what kind of networking do you wish for in the context of your workplace” however, some users picked car sharing and gave detailed statements. This is why car sharing is incorporated into the user model.

Regarding the recycling of electric vehicles, it can be determined that only 8 participants (3.7 %) have not given an answer to the question on how they plan to resell their

electric vehicle. This shows that most users think about recycling their vehicle, which makes it part of the user model. But recycling is not incorporated as an extra player as more than 99 % of the users plan to resell their vehicle over the Internet or via a local dealer, and both are already present in the user model.

Overall, we can derive all sections from the high amount of answers to direct questions or from being frequently mentioned in other open questions. Furthermore, all sections we have detected can also be logically linked to electric vehicles.

While the previously assumed sections in the model have been generally depicted using gerunds, nouns are used in the refitted and optimized model in order to clarify the actors.

In a more detailed elaboration (Fig. 4), the statements, needs and wishes of the participants have been affiliated in the respective sections.

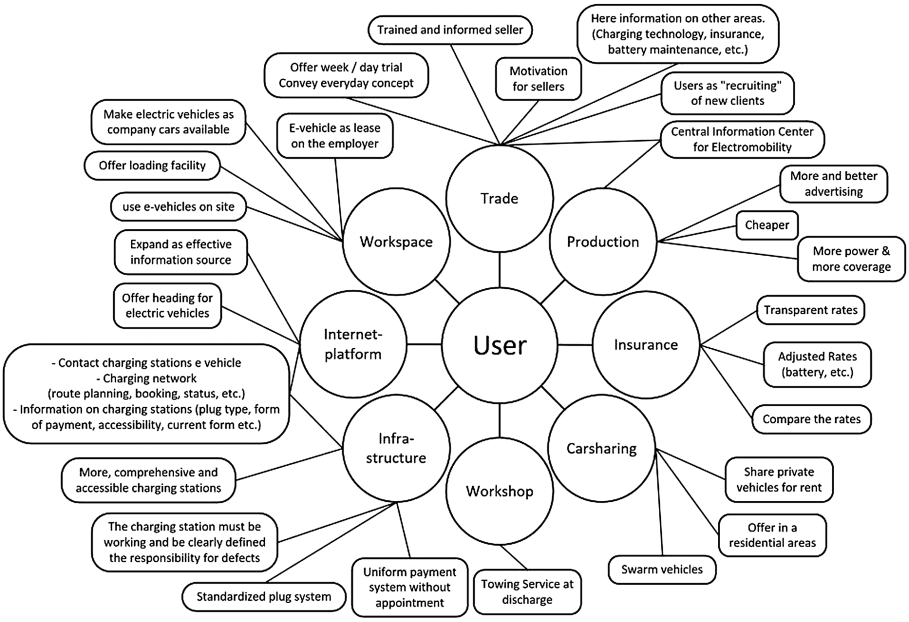

Fig. 4. Replies in corrected usage model

3.3 Results of the Bike Survey

The open interviews with various actors and user groups showed first pattern and content areas, that contribute positively to the further course of the current research project as well as to possible co-operations and follow-up projects with sustainable support of cycling and the "national cycling plan 2020" in the area "Bergisches Land".

The identification of beneficial potentials and current requirements is intended to help all involved actors to better achieve the common goal of a sustainable promotion of climate friendly mobility concepts with the example of e-bikes/pedelecs.

- Importance of cycling and pedelec use in the "Bergisches Land":
  - Cycling has no strong tradition in social life as it has in flat and rural areas
  - Especially in mountainous terrain like Wuppertal, pedelecs are very useful for frequent drivers
  - The mountainous terrain in Wuppertal makes normal cycling unsuitable for many people
  - Pedelecs are superior to conventional bicycles, especially under difficult topography conditions. It also provides a sensible solution for low-income groups by saving money on cars or public transport. But the high purchase price is an obstacle
  - E-bike/pedelec rental systems are only useful if the prices are below those of public transport
  - Potential first car or second car replacement, particularly for inner city driving, everyday work, small purchases and errands
  - Independence, environmental awareness, love for nature
  - Incentive systems and information for employers - inclusion in the operational mobility concept
- Infrastructure – Strengthening existing routes and stirring up regional interest municipally
  - Extension and marketing of existing routes
  - Targeted advertising of gastronomy and POI along bicycle routes
  - Navigation and route planning function for tourists in form of an application
  - Regularly occupied or non-existent public charging stations on well-known routes
  - Accessibility in public transport for cyclists-and pedelec users
  - Better interface to public transport
- Infrastructure – Developing new routes
  - New routes/courses with bike lanes
  - "But I don't like to ride on the main road, I look for secondary roads."
  - Charging stations as well as locking systems, bicycle boxes or storage facilities are necessary along routes
  - "All excursion destinations, such as the zoo, need charging stations."
  - Acquisition of infrastructure in a navigation and route planning function
  - Wuppertal is missing the linkage between University and the "bicycle city Wuppertal"
  - No bike lanes, charging stations and locking system at the University
  - Developing the infrastructure in the altitudes is more purposeful than agglomeration in the valley
- Improving appeal of Wuppertal's mobility concepts
  - Support of e-Bikes/pedelecs with events and theme routes
  - Campaign to improve prominence and acceptance
  - Cycling is a healthy and sporty way of transport and should be supported by the use of e-bikes/pedelecs
  - The use of e-bikes should be encouraged by benefits
  - Not always arrive sweaty and exhausted at the destination
  - Planning routes and tours free of topography

  - "Up the hill - down the hill - up the hill – I was flying! Incredible! Planning our tours used to take so much time and effort."
- Safety and legal basis – Considering risk potentials
  - Car drivers consistently underestimate pedelec cyclists, which recommends the provision of pure or separated bike lanes
  - The 25 km/h limit for e-bike/pedelec users is questionable, alternatively the limitation to 250 W motors has to be reconsidered
  - High risk potential due to operating the control panel while driving. Has to be manageable with both hands on the handlebar
  - In an accident, an emergency program should be activated, which makes the emergency call after a collision if the e-bike user does not respond
  - Incentives for the purchase or for taxation and limitations of CO2
- Application
  - Application for route recommendation and tourist options
  - Web platform and mobile application for exchange with users, support in case of problems
  - Displaying time, current speed and a battery level indicator
  - Route planning should be based on the battery level

3.4 Impact of the Bicycle Survey on the Route Recommendation Scheme

The following presents already identified topics and content areas of the route recommendation scheme, which we can now gradually investigate further through subsequent agile workshops, interviews and analyses.

By means of the usage phases, we developed a concept, which can calculate routes with a given length. Furthermore, criteria such as duration, rise, traffic volume, traffic interruptions, road situation, road type, road kind and road security and so forth, are weighted depending on their use, and are included in the calculation. In addition, it is possible to automatically incorporate individual or desired points of interests along the planed route.

The practical application of the implemented, use-centered algorithm resulted in a high acceptance rate, which needs to be elaborated in subsequent steps on the part of user guidance and equivalent functions.

To allow a comprehensive design of the algorithms and application, the analysis results are summarized and associated. With the user analysis, we generated requirements for the route recommendation that current applications do not offer. The primary way purposes "work" and "leisure" impose different demands on the navigation in order to meet the "basic needs" of users. The navigation should run on smartphones without Internet connection to allow navigation even with bad or missing reception. This should take as little time as possible to achieve an optimal user experience. In addition to the start and finish of the navigation, the system should be able to calculate courses and routes based on points of interest. Next to the route length, the important factors are, e.g. gradient, position, cultivation of the area and road surface.

4 Conclusion

4.1 Route Recommendation Scheme

Mobility is constantly transforming. With new and more and more performant possibilities of mobility in the shape of pedelecs, electric cars and the combination of multiple means of transportation as well as inter- and multimodal transport with respect to the ever increasing complexity due to user demands, developing an usage-based route recommendation scheme is of great interest and met with immense user approval. Furthermore, the development of such an usage-based recommendation scheme is not only of great value for end users, but also an important communication channel between users on the one hand and economy and communities on the other [1]. According to confirmed statements of experts, this concept significantly supports the maintenance and development of local and regional infrastructure, and also fulfils the requirements in the category of any points of interest.

4.2 Usage Model

In the context of early stages of product system engineering, the developed system proved its reliability.

Based upon mobility-related services, the components of the usage chain have been generalized using field observation, user interviews, etcetera and subsequently methods for pattern recognition. Deriving the usage aspect provides a standardized approach which enables sustainable product and service solutions as well as reliable advances in early development stages in the field of quality assurance. It is therefore possible to

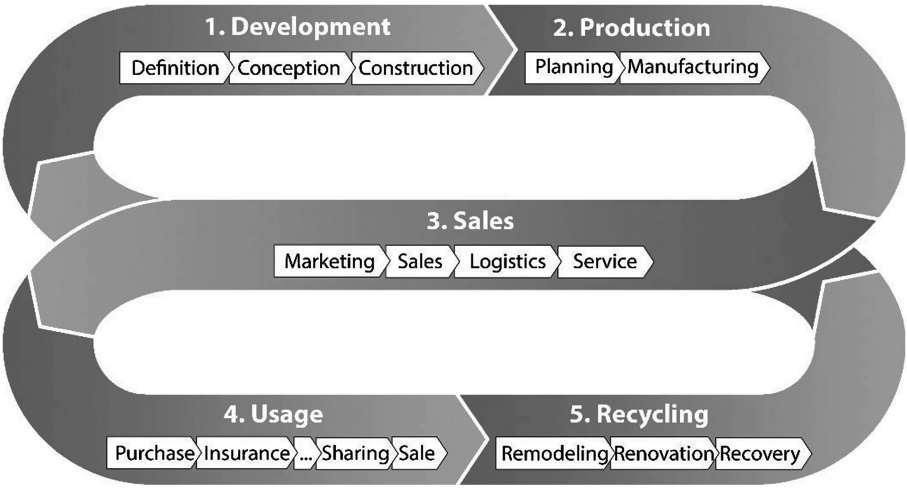

Fig. 5. Usage chain in product life cycle

contrast the derived requirements with the planned functions in order to verify the reliability of the ansatz in the context of human-technology interaction, and to estimate subsequent expenses.

An extensive, individual analysis and the corresponding research requires an increase of time requirements, personal expenses and potential costs within the development phases. But the application of the acquired usage guidelines reduces the required iterations and therefore positively influences the time investment within the development process. The demonstrated application of the usage phases can be embedded in the norm Ergonomics of Human-System-Interaction according to DIN EN ISO 9241-210 [3], and therefore contribute to meeting the usage requirements within the overall solutions (Fig. 5).

Furthermore, the collected methodical results are used as an "extended development approach" for additional product developments which are planned in the fields of "usage centered human-system integration" and/or "usage centered development tools for engineers".

In order to get a more complete picture of the different user-types of the product and therefore get user-groups, the understood (received) development model, the methods or approaches as well as the appropriate communication contents, need to be supplemented and analyzed based upon the environmental differences of the user. A laboratory for innovation-research, in order to investigate the efficiency of development would be an appropriate and expedient tool. Additionally, the transfer of the usage model to a software tool for development processes is planned in further steps.

References

1. Schimanski, S., et al.: Optimization approach and using Bezier-splines in navigation algorithms. In: Automotive, IEEE | ICCE - International Conference on Consumer Electronics, Las Vegas (2016)
2. Kruse, J.: Qualitative Interviewforschung: Ein Integrativer Ansatz. Beltz Juventa Verlag, Weinheim (2014)
3. ISO 9241-210: Ergonomics of human-system interaction - Part 210: human-centred design for interactive systems (2010)
4. Harrocks, C., King, N.: Interviews in Qualitative Research. SAGE Publications Ltd., London (2010)
5. Michael, H.: Software-Ergonomie: Theorien, Modelle und Kriterien für gebrauchstaugliche interaktive Computersysteme, 3 Auflage. Oldenbourg Wissenschaftsverlag (2009)
6. Hoppe-Graff, S.: Tagebücher, Gespräche und Erzählungen: Zugänge zum Verstehen von Kindern und Jugendlichen. In: Keller, H. (Hg.) Lehrbuch Entwicklungspsychologie, pp. S.261–S.294. Huber, Bern (1998)
7. Trautner, H.M.: Lehrbuch der Entwicklungspsychologie, 2 Aufl. Hogrefe, Göttingen (1997)