Development of an ICT Car Service Applying a Human-Centered Design

Yesool Cha[1], Jinman Kim[1], Byoungha Park[1], Youngchoong Park[1] and Seong-Dong Kim[1]
[1] Department of Realistic Media Platform Research Center,
Korea Electronics Technology Institute, Seoul, Korea
[e-mail: yscha@keti.re.kr, jmkim@keti.re.kr, bhpark@keti.re.kr, ycpark@keti.re.kr, sdkim@keti.re.kr]
*Corresponding author: Seong-Dong Kim

Received November 22, 2016; revised March 7, 2017; accepted April 2, 2017; published June 30, 2017

Abstract

Currently, various technological models and services are emerging because of the development of information and communication technology and the convergence of industries. The ICT car field is expanding because of technological convergence in the automobile industry. However, ICT convergence services are still being developed based solely on technology; characterization of users and their needs is lacking. Therefore, two types of ICT car services that apply human-centered design processes are developed in this study. These processes create services and models while considering the quality and functions of products based on users (instead of technology) when developing products or services. Usability evaluation was performed on the developed services; a human-centered design process was applied to the results to confirm that the derived services resulted in high satisfaction. In the future, these research results will provide useful applications when developing ICT car services and strategies.

Keywords: ICT Car Service, Human-Centered Design, Service Design, Usability Test, User eXperience

https://doi.org/10.3837/tiis.2017.06.015 **ISSN : 1976-7277**

1. Introduction

Infornation and communication technology (ICT) convergence for cars is accelerating as ICT functions in cars have become more integrated. ICT, in the form of electrics, electronics, and software in vehicles, is already essential for the competitiveness in the automotive industry. It's most notable effects are the improvement of driving performance and comfort, and the enhancement of both passive and active safety [1]. The ICT car is becoming a promising application domain of ubiquitous computing, which aims at assisting the driver with easier driving, less workload and less chance of getting injured. For this purpose, a ICT car must collect and analyze the relevant information about the driving task, i.e., context [2]. At present, the car is developing automatically and intelligently, automatically, getting more and more applications in production and logistics engineering. ICT car which is one of the most active fields within research, collects many new achievements of some academic subjects, such as automatic control, artificial intelligence, information fusion, sensor technology, image processing technology and computer etc. [3]. In particular, the rapid development of ICT enables people not only to dream the future life seen in Science Fiction (SF) movies with smart devices including smart phones, wearable devices, and smart glass, but also to have a solution of the kinds of environmental and social issues. The human-centered technology considers interactions not only between human and human, but also between human and Internet of Things (IoT) [4]. Existing studies show that the most important success factor in performing ICT convergent services is achieving diversity and increasingly meeting consumer needs. This result shows that understanding and analysis of customers (who are the receivers of services) is more important than cooperation between companies, and that technology can be used to spread ICT convergent services and encourage successful market entrance [5]. However, most ICT car services are being developed based on functions that do not reflect the characteristics of users.

Therefore, user groups who use services are defined. ICT car services that correspond to user needs were derived using a human-centered design method in Korea. Additionally, the derived services based on user groups were evaluated using various criteria. Evaluation plays an important role in product development lifecycle [6]. Evaluation is referring as an activity to assess the value of products with respect to a specific benchmark. This assessment can be used to gauge the product success in the real market and attract potential customers [7]. The implications of ICT car service development based on user groups are presented.

2. Related Work

2.1 Human-Centered Design

Human-centered design is a design method that is used to create human-centered solutions in various fields such as products, services, the environment, and an organization's composition. Human-centered design is based on the understanding of people, unlike existing methods, which are based on results. The 1990s saw the birth of human-centered design(HCD), which aims for equipment and systems designed to be easy to use, easy to understand, and worry-free from a user's viewpoint. This approach focuses attention on the user's workplace. In investigates user issues and solutions and aims to make ongoing improvements with user participation. The basic ideas behind HCD were formalized in "ISO 13407:1999

Human-centered design processes for interactive systems" in 1999 and have since found widespread application in many countries [8].

2.2 Human-Centered Design Process

A human-centered design toolkit was developed at the global design consulting company IDEO. The human-centered design process has three main steps at IDEO [9]. Detailed information is gained from users who are the subjects of design in the first (i.e., Hear) step through field investigations. Inspiration that becomes the core point of design is received. The second step is the Create step. The fundamental problem is understood based on the data collected during the Hear step; the main purpose is to create a realistic solution. The third step is the Deliver step. In this step, a prototype that proposes a sustainable solution that can be implemented via evaluation and revision of the proposed solution is presented.

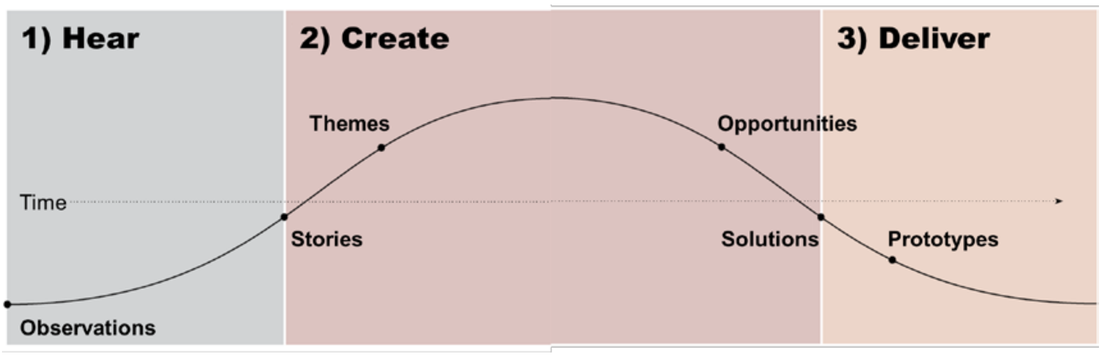

Fig. 1. Human-Centered Design Process

2.3 Determining ICT Car User Characteristics

ICT car user characteristics were determined so as to accurately reflect user needs. As the ICT car market is a new market, potential virtual users, those who have the intention of driving ICT cars in the future, and who currently drive cars, were targeted. Based on research that has identified digital lifestyle types and research that segments car users according to lifestyles [10], we determine user group characteristics; four types of user characteristics were obtained. Their four characteristics are shown in the figure below.

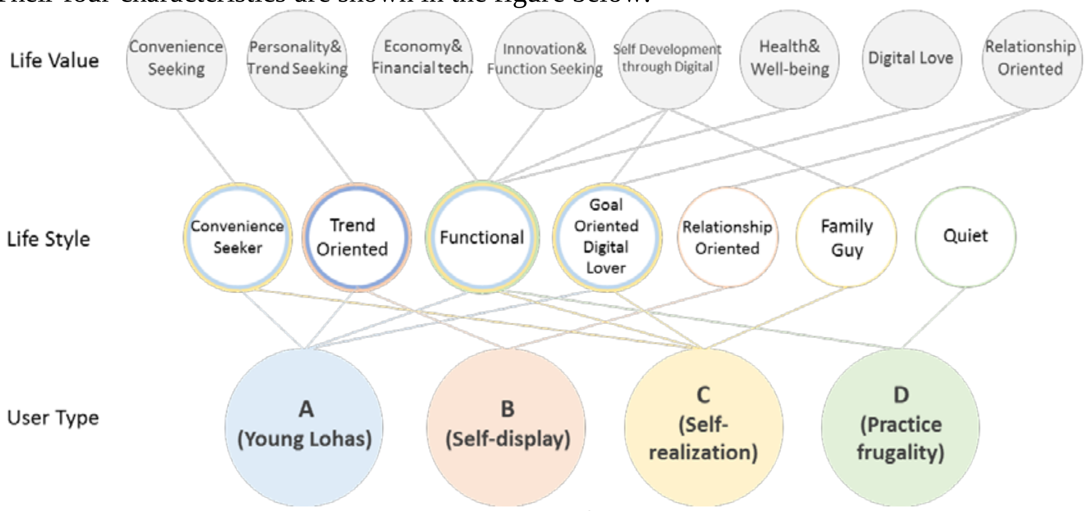

Fig. 2. Characteristic of ICT Car User

3. Method

3.1 Hear

Open questions were asked so as to obtain detailed opinions on the kinds of ICT car services that users expect. An in-depth interview investigation method that obtains detailed opinions on a particular topic was used. Ten car users associated with each user characteristic (defined above) were targeted for the interview and a driving course (starting from entering the car, until the point of completing parking) was observed during the interviews.

Fig. 3. Hear step outcome 1: In-depth Interview

3.2 Create

3.2.1 Customer Journey Map

User experiences were sequentially listed. Data collected during the interview was organized into a single customer journey map. The customer journey map is composed of touch points that occur after a significant experience between the user and the service. The contact points of the event occurrences based on the lifestyle of each user were defined as touch points. The contexts, actions, emotions, and needs of users were derived from the customer journey map.

3.2.2 Persona

The affinity diagram analysis method was used to reanalyze the interview data for clearer analysis of user characteristics and needs. Using this created persona, which easily describes user needs with more efficiency based on a virtual character, was created [11]. A total of four personas were created; one of the personas is shown in the figure below.

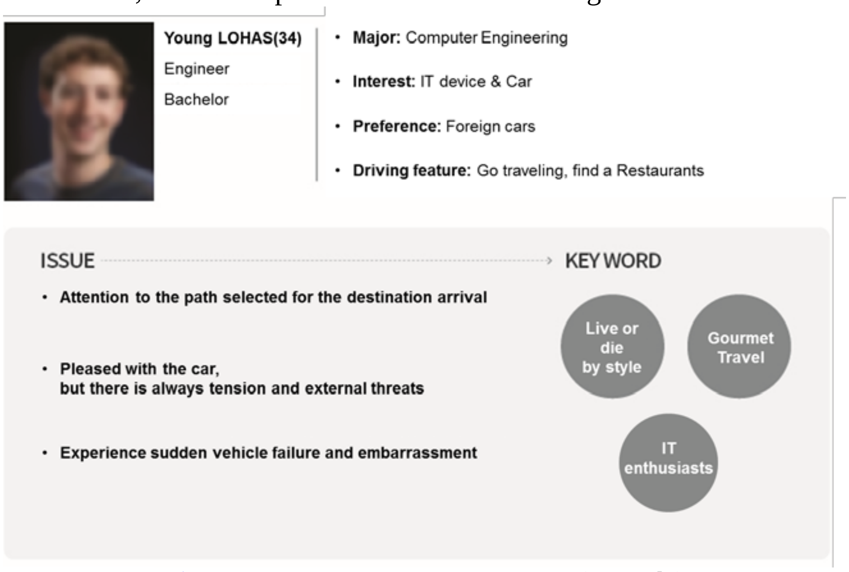

Fig. 4. Create step outcome 1: Persona(example)

3.2.3 Service Blueprint

Two types of ICT car service to meet user needs were obtained: smart care service and smart maintenance service. Smart care service is a service that enables safe and convenient driving by providing ICT services to drivers; it is composed of four specific services. Smart maintenance service is a service that improves convenient and safe driving by automatically managing and providing the history of consumables and driving habits; it is composed of six specific services. A service blueprint was created for specification of the obtained services. The service blueprint is a tool used for service innovation, but has also found applications in diagnosing problems with operational efficiency and can be used to conceptualize structural change. The blueprint shows processes within the company, divided into different components, which are separated by lines [12].

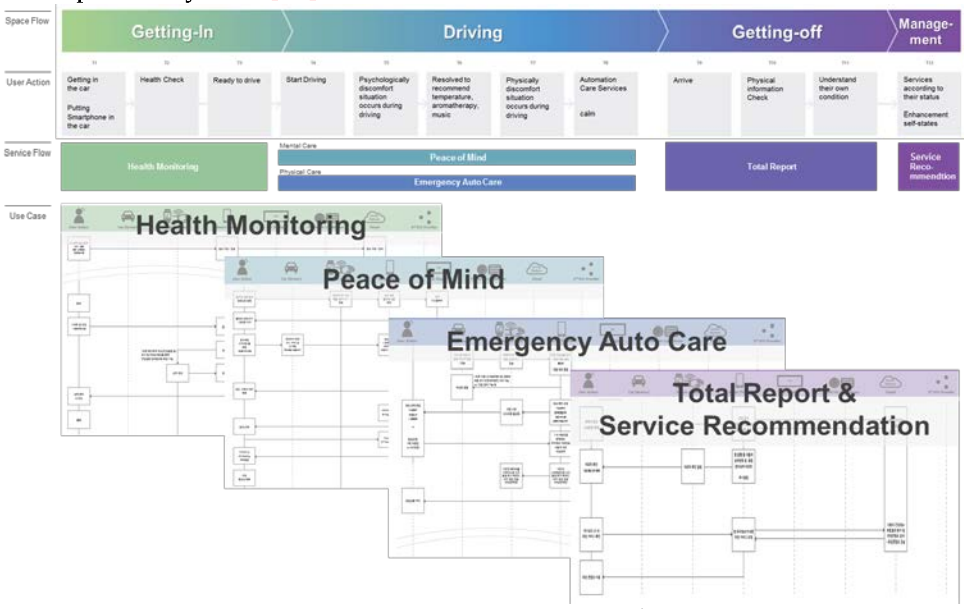

Fig. 5. Create step outcome 2: Service Blueprint of Smart Care Service

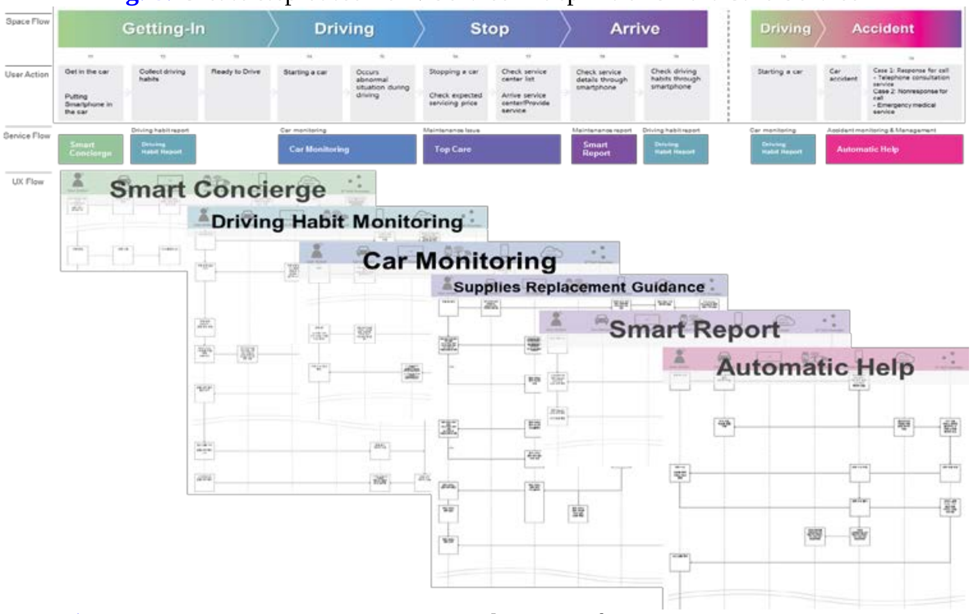

Fig. 6. Create step outcome 3: Service Blueprint of Smart Maintenance Service

The functions included in the smart care service and smart maintenance service are shown in the following table.

Table 1. Service Definition

No.	Smart Care Service		Smart Maintenance Service	
1	**Health Monitoring**	Physiological signals are measured by sensors on the steering wheel. Data is analyzed to determine user's current condition.	**Smart Concierge**	Vehicle information is automatically obtained, saved, and managed (linked with the service center and the insurance company).
2	**Peace of Mind**	Current sensitivity condition is obtained when the user receives stress while driving. Visual and auditory content is provided to relieve this issue.	**King' s Drive**	Vehicle driving data is automatically saved so as to obtain driving habits.
3	**Emergency Auto Care**	Vehicle ventilation when detecting drowsiness while driving and relieve drowsiness by requesting a call to the call center.	**Don' t Mind**	Provide a response when a vehicle fault occurs or when consumables must be replaced.
4	**Emergency Home Care**	Relay information about an emergency situation that occurs in the driver's house during driving.	**Top Care**	Items requiring replacement are indicated. Cost estimates and nearby service centers are provided.
5	**Total Report**	Reports a change of the user sensitivity condition, which is shown during driving and when arriving at a destination.	**Smart Report**	After maintenance, equipment maintenance history is provided to various devices (phone/watch/IVI).
6	**Service Recommendation**	Recommends nearby stores based on sensitivity condition during driving or after drive ends.	**Automatic Help**	Responds to emergency situations when an accident occurs while driving (phone call to an acquaintance or Emergency Call Service).

3.2.4 Wireframe

A wireframe was created to visualize the overall architecture of the two final services. The wireframe helps developers to understand service functions and designers to smoothly determine design concepts and determine whether user needs are thoroughly met. The layout, components, and interactions on the device screen used in this service [smart phone, smart watch, IVI (in-vehicle infotainment)] were included for manufacturing.

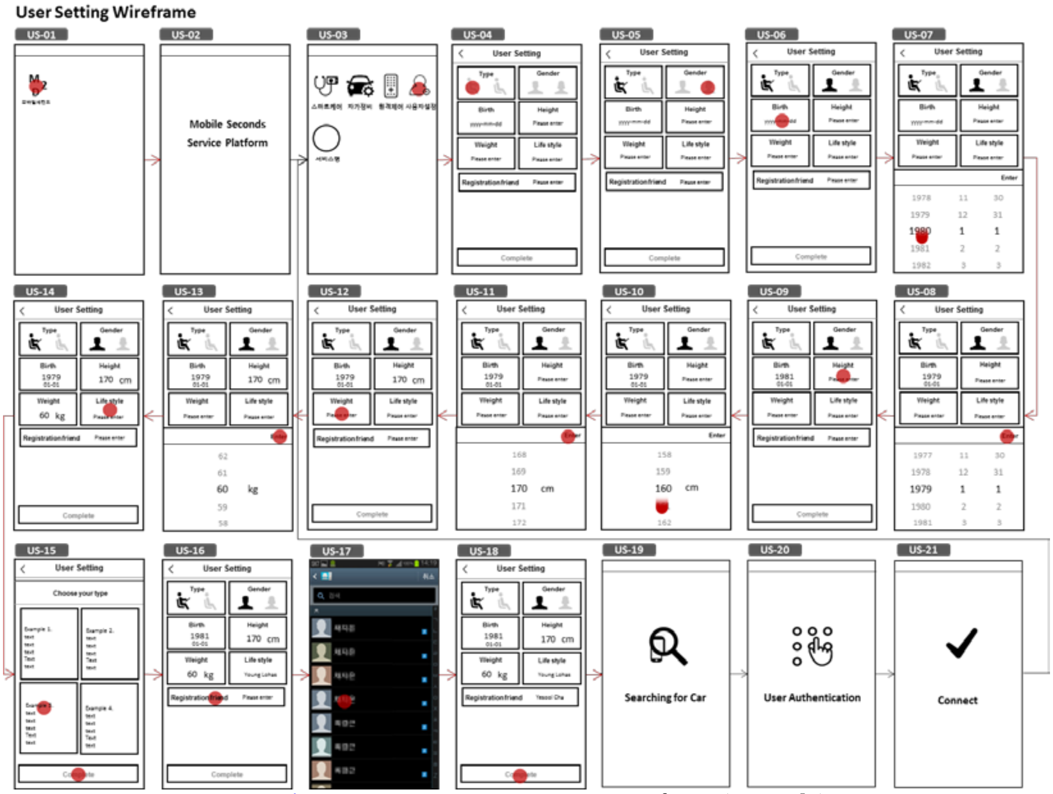

Fig. 7. Create step outcome 4: Wireframe(example)

3.3 Deliver

3.3.1 GUI Design

Visual factors that can influence the user experience were included to improve the GUI (graphic user interface) design. The development environment of each device was analyzed and the UI (user interface) guideline was used to follow the basic rules of design.

Fig. 8. Deliver step outcome 1: GUI Design for Smart Phone

Fig. 9. Deliver step outcome 2: GUI Design for IVI & Smart watch

3.3.2 Evaluation

3.3.2.1 Demonstration Development

In this study, the demonstration system shown in **Fig. 10** was developed to evaluate the usability of the service based on HCD. This system presents a virtual driving environment and the service developed through this system can be indirectly experienced by users. This system, shown in **Fig. 10**, is composed of (a) the driving simulation, (b) a body signal sensor, (c) an IVI board and display, and (d) a smart watch. The body signal sensor is embedded in the vehicle handle; it is used to evaluate service usability. The IVI board collects data regarding the vehicle (e.g., sensor information detected in a car accident or driving speed) and delivers it to the cloud server. We assume that the smart watch is worn by the driver.

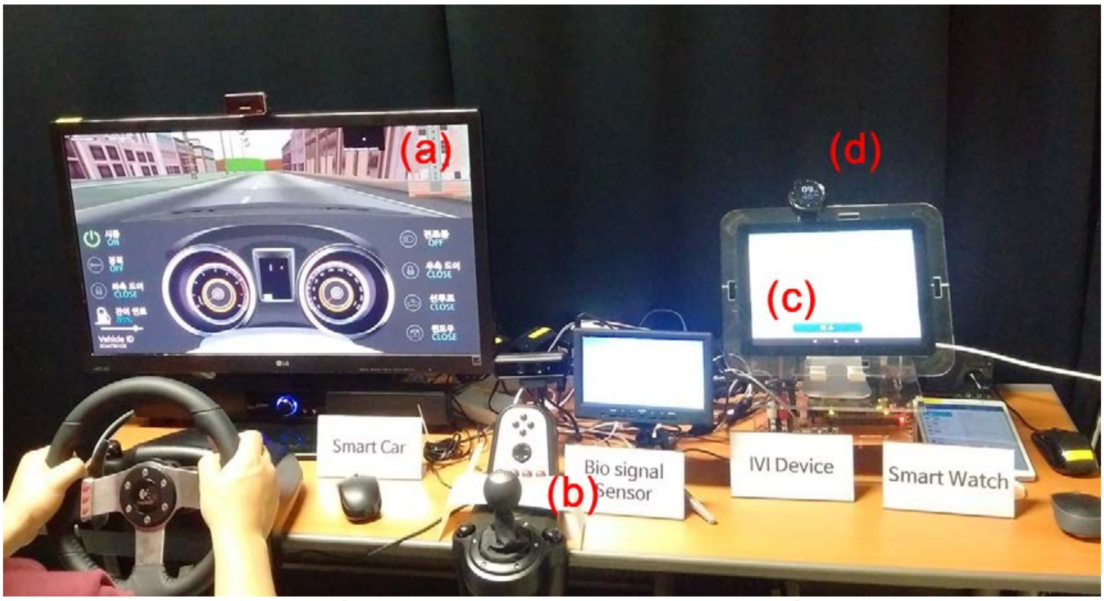

Fig. 10. Deliver step outcome 3: Demonstration Development

The hardware and software of the system components are shown below.
(a) Driving simulation - Unity3D (v 5.x), LogitechWheel Library
(b) Body signal - PPG, SKT
(c) IVI board - MC9S08DZ60, Android 4.3 by FreeScale
(d) Smart watch - G Watch R, Android Wear by LG

The demonstration system must satisfy the conditions below for smooth usability evaluation of the developed service.

(1) The system must provide basic driving condition information such as speed or RPM to users as part of the service experience.
(2) The system must provide vehicle operating functions such as ignition and gear changes to users to provide the service experience.
(3) The system must measure and output body information to users.
(4) The system must simulate an emergency situation.
(5) The system must maintain communication among system components.

3.3.2.2 Usability Test Design

Notifications, service reviews, preliminary surveys, task performance evaluations, post-surveys, and in-depth interviews were performed to ensure effective usability evaluation. KS-SQI (Korean Standard-Service Quality Index), which is a model developed to reflect industry and consumer characteristics and a comprehensive index that shows the overall quality level of services, was used as the evaluation index for investigating the level of satisfaction with service quality for targeted customers who have purchased and used the service. Research on service quality proliferated after the definition provided by Crosby in 1979. SERVQUAL by PZB, and SERVPERF by Cronin and Taylor are accepted as the most representative theoretical models. KS-SQI was developed for measurement using SERVPERF in real-world applications, using a unified index that can be applied to all industries using the SERVQUAL model. KS-SQI adds 3 perspectives based on the five perspectives and 22 items of the SERVQUAL model; it is classified into four service achievement related service achievement perspectives and four measurement factors of process perspectives that customers experience during the service providing procedure. Through re-establishment of the model, KS-SQI measurement factors are classified into two achievement perspective factors related to service achievement that is finally delivered to customers, and five process perspective factors related to customer experience (in the service-providing procedure). Using the seven perspectives shown in the table below, survey items for evaluating the service were written.

Table 2. Components of KS-SQI

Field	Perspective component	Contents
Achievement	**Primary Needs Fulfillment**	Satisfies basic desires of users using the service.
	Unexpected Benefits	Provides additional services and different benefits to customers, as compared to other companies.
Process	**Reliability**	Reliability that customers associate with the service provider: the service provider possesses technology and knowledge required to provide honesty, integrity, and service.
	Individual Empathy	Polite and kind customer response attitudes: Responds to customers with high sociability and a polite attitude.
	Positive Assistance	Will to quickly provide service that meets the needs of customers.
	Accessibility	Convenience (of time and place) provided by the service.
	Physical Evidence (Media Tangibles)	Physical evidence used for service evaluation.

3.3.2.3 Usability Test

Notifications, service reviews, preliminary surveys, task performance evaluations, A preliminary survey was performed to select suitable subjects among ICT car users. By analyzing the preliminary survey data, 30 survey subjects with 60% or higher correspondence with a persona were selected as usability evaluation subjects. Usability evaluation was performed in January, 2016, using a demonstration system in a testbed that simulated the vehicle environment.

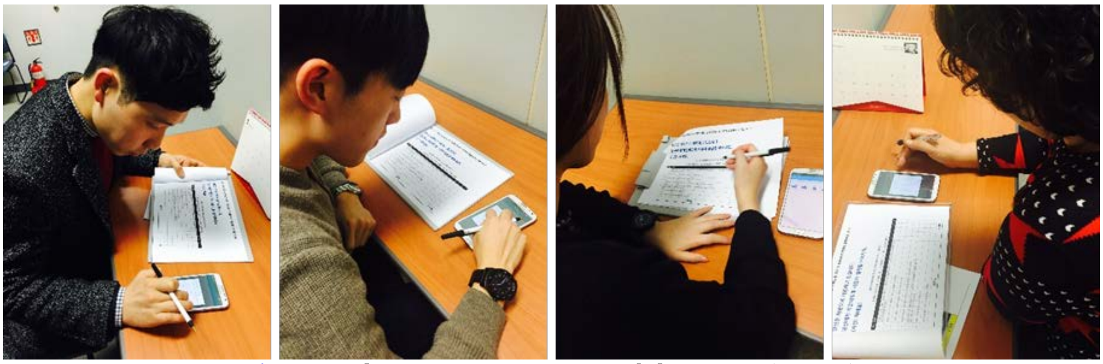

Fig. 11. Deliver step outcome 4: Usability Test 1(Survey)

Fig. 12. Deliver step outcome 5: Usability Test 2(Task)

3.3.2.4 Usability Test Result

The results confirmed that the basic information of subjects corresponded to basic persona information, as shown in **Table 3**.

Table 3. Characteristics of the study sample

User Group	Item	Gender	Age	Agreement (%)
A	Result	M	30	80
		M	31	80
		F	29	80
		F	27	80
		M	27	80
		M	27	60
		F	32	80
	Persona		20s, 30s	**Correct**

B	**Result**	F	57	100
		M	27	80
		M	37	60
		M	24	60
		M	65	80
		F	47	60
		F	29	80
	Persona		40s	**Correct**
User Group	**Item**	**Gender**	**Age**	**Agreement (%)**
C	**Result**	M	59	80
		M	30	80
		F	27	80
		F	48	80
		F	27	80
		M	24	80
		M	29	100
		M	29	80
		M	29	80
		M	25	60
	Persona		30s and 40s	**Correct**
D	**Result**	M	59	100
		F	49	66
		F	29	100
		F	65	100
		F	49	66
		M	25	66
	Persona		40s or more	**Correct**

Service satisfaction scores were obtained on a five-point scale after performing tasks based on the scenario. SPSS Statistics 23.0 was used to analyze the obtained data based on user characteristics. ANOVA (one-way layout) was conducted. Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures. It is used in the analysis of comparative experiments, those in which only the difference in outcomes is of interest. The F-test is used for comparing the factors of the total deviation. For example, in one-way, or single-factor ANOVA, statistical significance is tested for by comparing the F test statistic.

$$F = \frac{variance\ between\ treatments}{variance\ within\ treatments}$$

$$\mathrm{F} = \frac{MS_{Treatments}}{MS_{Error}} = \frac{\dfrac{SS_{Treatments}}{(I-1)}}{\dfrac{SS_{Error}}{(n_T - I)}}$$

where MS is mean square, I = number of treatments and n_T = total number of cases to the F-distribution with I – 1, n_T - I degrees of freedom [13].

Before variance analysis, outliers from each data set were investigated using scatter plot analysis. As a result, three and four data points were excluded from the smart care service data and the smart maintenance service data, respectively. Therefore, data from 26 users of smart care service and 27 users of smart maintenance service were analyzed.

The table below shows the results of variance analysis with an *F* value of 3.237 with a *p* value of 0.042. These results are significant within a 5% significance level. Therefore, the null hypothesis, i.e., that smart care service satisfaction is not influenced by ICT car user characteristics, was rejected. The ICT car user characteristics influence user satisfaction with the smart care service.

Table 4. ANOVA Result of Smart Care Service

ANOVA					
Satisfaction with Smart Care Service					
	Square sum	Degrees of freedom	Mean square	***F***	**Significance Probability**
Group-between	1.214	3	0.405	**3.237**	**0.042**
Group-within	2.751	22	0.125		
Total	3.965	25			

The table below shows the results of variance analysis with an F value of 3.403 and a p value of 0.035; the results are significant with a 5% significance level. Therefore, the null hypothesis, namely that the ICT car service satisfaction is not influenced by user characteristics, was rejected. The ICT car user characteristics influence satisfaction with the smart maintenance service.

Table 5. ANOVA Result of Smart Maintenance Service

ANOVA					
Satisfaction with Smart Maintenance Service					
	Square sum	Degrees of freedom	Mean square	***F***	**Significance Probability**
Group-between	1.025	3	0.342	**3.403**	**0.035**
Group-within	2.308	23	0.1		
Total	3.333	26			

Using ANOVAs to compare the difference between satisfaction with each service based on user group, the null hypothesis was rejected for both services at less than 5% significance level, indicating that that ICT car satisfaction is influenced by ICT car user characteristics.
Additionally, the mean value of the total data of 30 usability test participants was analyzed. As a result, the smart care service received 4.12 points (the maximum was 5 points) and the smart maintenance service received 4.34 points (again, the maximum was 5 points), indicating that both services resulted in high satisfaction.

Fig. 13. Result of Satisfaction

As a results of analysis of mean values based on user characteristics, various scores from 3.99 points to 4.49 points were distributed.

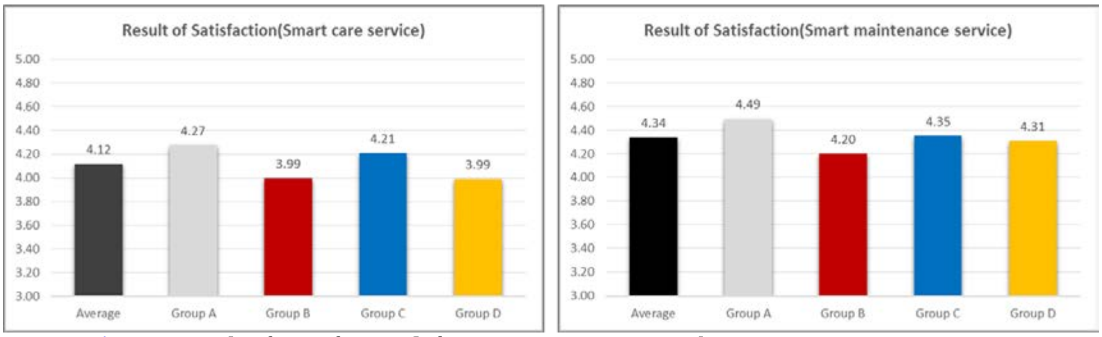

Fig. 14. Result of Satisfaction(left: smart care service, right: smart maintenance service

4. Conclusion

ICT car services will become more diversified and the market will continue to grow in the future. Despite the significance of understanding and analyzing users in promoting ICT car services and successful market entry, current services are being provided based primarily on technology. In this study, target users were defined so as to provide service solutions in the ICT car market. A human-centered design with Hear, Create, and Deliver stages was applied to develop two types of services that reflect user needs (i.e., smart care service and smart maintenance service). Additionally, usability evaluation was conducted on the two developed types of service for 30 subjects so as to investigate service satisfaction. Variance analysis was conducted to analyze the data collected through the usability evaluation based on user characteristics. The results show that user characteristics influence ICT car service satisfaction. Higher satisfaction can likely be provided if target users are further segmented when developing services. was Additionally, we found that users have higher satisfaction for services that automatically manage the car itself, as compared to services that care for users by confirming satisfaction level based on services. We found high satisfaction scores of 4 or higher on a 5-score scale for the two types of ICT car services, which shows that the services obtained by applying human-centered design processes can satisfy user needs. In the future, these research results can provide useful implications when developing ICT car services and identifying strategies.

Acknowldegement

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIP) (No. B0101-15-0426, Development of the Smart convergence SW platform based on open software for new convergence services in mobile seconds branch).

References

[1] Christian Buck, Alexander Camek, Ljubo Mercep, Hauke Stahle, Alois Knoll, "The Software Car: Building ICT Architectures for Future Electric Vehicles," in *Proc. of Electric Vehicle Conference (IEVC), 2012 IEEE International*, pp. 1-8, March 4-8, 2012. Article (CrossRefLink)

[2] Jie Sun, Yongping Zhang, Kejia He, “Providing context-awareness in the smart car environment,” in *Proc. of Computer and Information Technology (CIT), 2010 IEEE 10th International Conference*, pp.13-19, 2010. Article (CrossRefLink)
[3] WANG Yong-ding, NIE Li-na, “Design of Smart Car Speed Control System Based on Fuzzy Control,” in *Proc. of Artificial Intelligence and Computational Intelligence (AICI) 2010 International Conference*, Vol. 2, pp.516-519, 2010. Article (CrossRefLink)
[4] Hyungkeuk Lee, Sung-Hee Kim and Hyun-Woo Lee, “Advanced Technologies for Smart Exhibition Guide Service,” in *Proc. of Information and Communication Technology Convergence (ICTC), 2015 International Conference*, pp.864-867, 2015. Article (CrossRefLink)
[5] Byung-Young Kang, Jin-Yong Park, Han-Kuk Hong, “A Study on Effects of Success Factors and Strategics of Convergence Products,” *The Korea Association of Information Systems*, vol. 17, no. 1, pp.45-62. 2008. Article (CrossRefLink)
[6] Ana M. Moreno, Ahmed Seffah, Rafael Capilla and Maria-Isabel Sanchez-Segura, “HCI Practices for Building Usable Software,” *Computer*, vol. 46, no. 4, pp.100-102, 2013. Article (CrossRefLink)
[7] Lim Tek Yong, “User Experience Evaluation Methods for Mobile Devices,” in *Proc. of Innovative Computing Technology (INTECH), 2013 Third International Conference*, pp.281-286, 2013. Article (CrossRefLink)
[8] Junichi Murashima, “Preface Special Issue on Human-Centered Design,” *Fujitsu Sci Tech J 2009*, vol. 45, no. 2, pp.141-142, April 2009. Article (CrossRefLink)
[9] IDEO, “Field Guide to Human-Centered Design,” Chicago, pp.20-21. 2015. Article (CrossRefLink)
[10] Jung, “A study on market segmentation of private vehicle users in domestic market based on lifestyles,” *Korea Corporation Management Association*, Vol 20, No. 5, pp. 63-80, 2013. Article (CrossRefLink)
[11] Mika Hiltunen, Markku Laukka, Jari Luomala, “Professional Mobile User Experience,” Cromland, August 1, 2002. Article (CrossRefLink)
[12] Wikipedia : https://en.wikipedia.org/wiki/Service_blueprint.
[13] Wikipedia : https://en.wikipedia.org/wiki/Analysis_of_variance

Yesool Cha received the M.S. degrees in Emotion Engineering from Sangmyung University, Korea. She has been a researcher in Korea Electronics Technology Institute, Seoul, Korea since August 2014. Her research interests include User eXperience, Human Computer Interaction, and Emotion Engineering.

Jinman Kim received the Ph.D. degrees in Computer Science from the Sangmyung University, Korea. He is a research professor in Sangmyung University, Seoul, Korea. His research interests include Big-data, Machine learnig, and Internet of Things(IoT).

Byoungha Park received the M.S. degrees in Computer Engineering from Sejong University, Korea. He has been a researcher in Korea Electronics Technology Institute, Seoul, Korea. His research interests include VR/AR, E-training, and Learning Management System(LMS).

Youngchoong Park received the Ph.D. degrees in Computer Engineering from Sejong University, Korea. Currently, he is a director of VR/AR Research Center at Korea Electronics Technology Institute(KETI) in Korea. His research interests include User eXperience, Human Computer Interaction and VR/AR.

Seong-Dong Kim received the BS and MS degrees in electronics engineering from Kyungpook National University, Korea, in 1983 and 1990, respectively, and the PhD degree in electrical engineering from Texas A&M University in 1996. Currently, he is a director of Mobile Second Research Center at Korea Electronics Technology Institute(KETI) in Korea. Prior to that, he held a faculty position at computer engineering department of Dongeui University in Korea. He served as a research engineering staff to many institutes, including ETRI(Electronics and Telecommunications Research Institute), Samsung Electronics, Haedong Information & Communications, and Dgstar in Korea. His research interests include wireless networks and mobile computing, parallel and distributed systems, and ambient intelligent computing.