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GOOGLE GLASS AS INDUSTRY 4.0 TECHNOLOGY

Abstract. The rapid technical developments and the actual discussion about Industry 4.0 demonstrates the need for more effective and efficient technologies to be able to handle upcoming business demands. Those technologies have not just to cover data production, transmission, and integration, but especially increased heterogeneous handling requirements of potential user groups, e.g. employees on the shop floor. Such a technology might be smart data glasses and as an instanciation of this class Google's product *Glass*. Especially top management representatives or managers still recognise a certain potential of the device. Based on developed applications, a simultaneous transmission of data is possible. The BMW Manufacturing Co. announced that it developed an app improving the quality especially of videos. This software allows a loop of two minutes (in the background) so that the appearance of errors or certain issues can better be identified without searching within a video. Besides, the data glasses synchronise itself with a smartphone so the data are available decentr

Keywords: technology, industry, technology evaluation, smart glass

OKULARY GOOGLE GLASS JAKO PRZEMYSŁ W TECHNOLOGII 4.0

Streszczenie. Szybkie postępy techniczne i faktyczna dyskusja na temat sektora 4.0 pokazują potrzebę bardziej efektywnych i wydajnych technologii, aby móc obsłużyć przyszłe wymagania biznesowe. Technologie te nie tylko obejmują produkcję, transmisję i integrację danych, lecz przede wszystkim zwiększone heterogeniczne wymagania dotyczące obsługi potencjalnych grup użytkowników. Taką technologią mogą być inteligentne okulary pozwalające na analizę danych, jak np. produkt Google Glass. Z analizy wynika, że najwyżsi przedstawiciele kierownictwa i menedżerowie rozpoznają potencjał urządzenia. Podczas wykorzystywania rozwiniętych aplikacji możliwy jest przy jego użyciu symultaniczny przesył danych. Firma BMW Manufacturing Co. ogłosiła, że opracowała aplikację poprawiającą jakość tego przesyłu, zwłaszcza w przypadku filmów wideo. To oprogramowanie umożliwia pętlę dwóch minut (w tle), dzięki czemu można lepiej zidentyfikować pojawienie się błędów lub niektórych problemów bez

wyszukiwania w obrębie filmu wideo. Poza tym omawiane okulary synchronizują się ze smartfonem, dzięki czemu są na nim dostępne przetwarzane dane.

Słowa kluczowe: technologia, przemysł, ocena technologii, smart glass

1. Introduction

The rapid technical developments and the actual discussion about Industry 4.0 demonstrates the need for more effective and efficient technologies to be able to handle upcoming business demands. Those technologies have not just to cover data production, transmission, and integration, but especially increased heterogeneous handling requirements of potential user groups, e.g. employees on the shop floor. Such a technology might be smart data glasses and as an instanciation of this class Google's product *Glass*. A lot of developers worked on applications to make smart glasses useable. But, there are some felt obstacles in the practical experience, yet, which led to a considerably smaller amount of users than expected. This leads to the paper's goal to clarify the user's expectations and feelings regarding smart glasses in business scenarios.

There is already quite a number of companies testing Google's product Glass to identify, whether this technology offers opportunities on their shop floors. Examples are BMW at Spartanburg, where the proof of concept is placed within the quality management, or the logistics department of Volkswagen at Wolfsburg. Both companies share the goal to identify appropriate business cases, but this requires well established guidelines, so that also not just big, but also small and medium sized companies (SMEs) are able to apply them in a business case evaluation process.

We have examined the user's experiences by performing expert interviews and a survey applying the technology acceptance model. First, the area of discourse is defined followed by some theoretical foundations including concepts like Industry 4.0 and internet of things. In the end, the results of the survey could be evaluated by the Smart PLS Tool, to be able to discuss the proposed research questions.

2. Industry 4.0 and Smart Glasses

With the product *Glass* of Google Inc. and with respect to the current developments of Industry 4.0, Glass, as another available mobile technical device, adresses technology challenges in a business environment to be able to bring benefits into industries' production environments. This chapter presents initially the topic of Industry 4.0 and illustrates *Glass* as

one mobile technology within this domain. Additionally, it explaines the tool *Glass* from a technology oriented perspective as representation of the class of data goggles products.

2.1. Development and Characteristics of Industry 4.0

The usage of water and steam power led to the first industrial revolution in the mid-19th century. The subsequent mass production using assembly lines was leading to the next industrial revolution, whereupon the digital revolution is accomplished by the insertion of IT and electronics. Meanwhile, we passed the threshold of the fourth industrial revolution – Industry 4.0. This term appeared during Hannover Fair in 2011 for the very first time and is actively used since 2013 with the idea of a research agenda and implementation of appropriate solutions by Deutsche Forschungsgesellschaft (DFG) and the Bundesministerium für Bildung und Forschung (BMBF)[1]. Due to the development of the Internet of Things, defined as "networking of objects to the Internet, so that these objects communicate independently on the Internet and so do various tasks for the owner"[2], grow real and virtual worlds together. This also happened in production environments. This process is supported under the umbrella term Industry 4.0 as future oriented project of the German Federal Government[3]. The aim is to design a smart factory to make German industry competitive for future challenges in the production sector[4]. Besides the Internet of Things, a technical basis for the Industry 4.0 and therefore a smart factory is formed by cyber physical systems. Cyber physical systems link “real (physical) objects and processes [...] with information processing (virtual) objects and processes through open, partly global, anytime interconnected information networks”[5].

A *Smart Factory* is defined by *Smart Objects*[6] and therefore characterized by self-organizing production and logistic systems. So, the communication of systems, people, and products as smart objects is the major distinguishing part. This means that "the intelligent products are (...) located at any time, be clearly identified" and they know “their history, their current status, as well as alternative routes to the destination state”[7]. RFID chips or QR/bar codes on these objects contain relevant information that can be read and transmitted by scanner and computer to allow an automated process. Such a Smart Factory is a part of the discussion about the Internet of Things (IoT). IoT designates “the linking of objects to the Internet, […] so that these objects communicate independently on the Internet and so they can perform

[1] Bundesministerium für Bildung und Forschung - Industrie 4.0, http://www.bmbf.de/pub/ broschuere_Industrie-4.0-gesamt.pdf, 2014.
[2] Lackes R., Siepermann M.: Gabler Wirtschaftslexikon, Stichwort: Internet der Dinge, Springer Gabler Verlag (Herausgeber), http://wirtschaftslexikon.gabler.de/Archiv/ 1057741/internet-der-dinge-v4.html, 2015.
[3] Bundesministerium für Bildung und Forschung, BMBF - Industrie 4.0, http://www.bmbf. de/de/9072.php, 2014.
[4] Ibidem.
[5] Schleipen M.: Begriffsdefinitionen rund um Industrie 4.0, http://www.iosb.fraunhofer.de/ servlet/is/48960/, 2014.
[6] Bundesministerium für Bildung und Forschung, BMBF - Industrie 4.0, http://www.bmbf. de/de/9072.php, 2014.
[7] Kagermann H.: Chancen von Industrie 4.0 nutzen, [in:] Hompel M. ten, Vogel-Heuser B., Bauernhansl T. (eds.): Industrie 4.0 in Produktion, Automatisierung und Logistik: Anwendung, Technologien, Migration. Springer Vieweg, Wiesbaden 2014, p. 603-614.

a variety of tasks for the owner"[8]. The current status of an industrial production is characterized by a high customization of products considering a highly flexible production, a so-called Mass Customization[9]. The production is connected with quality services. Customers and business partners can be directly integrated into the corresponding value creation processes. Due to an intelligent observing and decision making, monitoring and optimization of businesses can be done in near real time. Accordingly, appropriate automation technologies, which are characterized by a higher degree of intelligence, are of particular importance. Especially, self-tuning, self-configuring, self-diagnosis, and cognitive processes are necessary[10].

Within the scope of the development of supporting measures of Industry 4.0, the BMBF sees currently four different topic areas of major importance: SMEs, standards and IT architectures, IT security, and qualifications[11]. On account of only a few already existing guides as well as hardly defined implementation standards, suitable supporting activities of the Federal Ministry are laid out particularly for SMEs. They lead to a specific tool development for economic efficiency considerations. These assessments support a future ability of technologies for Industry 4.0. Besides, adoption processes are made easier with the help of specific and transferable solutions. Introduction recommendations and conversion strategies are developed, too. In view of a rising complexity within the scope of a software development and automation, the development is unavoidable economically load-bearing to gain efficient and reliable software systems. Besides, resulting IT architectures, in spite of the rising complexity, should be usable rather more easily. The challenge is in the area of data security and knowledge protection. But this is already related to an IT-security research program of the Federal Government so that a solution should be available, soon. The linkage of real and virtual reality includes challenges to working processes, working contents, and appropriately skilled workers. The need in systematised qualification profiles rises massively and up to now, merely first qualification attempts exist. Due to this reason and as a result of an IT summit in 2014, other strategies should be triggered by the BMBF adressing labour organisation or competence development.

Smartglasses are a notable technical device for Industry 4.0, because an important „improvement potential […] is seen by the exchange of the product data"[12]. Besides, Glass could be a suitable interface between machines and humans and therefore serves as a functional tool. A more efficient data exchange can be realizied to reduce a too time intensive information distribution[13]. Other challenges show the subjects security and standardization[14]. "So that new technologies can be used like the mobile Internet and Cloud for the real time – interlinking,

[8] Lackes R., Siepermann M.: op.cit.
[9] Bundesministerium für Bildung und Forschung, BMBF - Industrie 4.0, http://www.bmbf. de/de/9072.php, 2014.
[10] Kagermann H.: op.cit.
[11] Bundesministerium für Bildung und Forschung, BMBF - Industrie 4.0, http://www.bmbf. de/de/9072.php, 2014.
[12] Hoffmann D.: Industrie 4.0 – Hype und Herausforderung. Automotive IT, 2015, p. 2.
[13] Ibidem.
[14] Ibidem, p. 3.

[for example], of the production and whole value added chains, now it is about sure solutions for the wireless communication“[15] like the use of data glasses. An important factor shows the use of a suitable applications to realize and improve a processing of suitable information[16].

2.2. Glass as one of the Mobile Technologies

Glass was developed in the research department *Google [X]* at *Google Inc.* since 2011. The department's responsibilities are to develop new technologies and thus contribute to the company’s progress. Glass was initially introduced in April 2012 and made public in February 2013, which was the start of the so-called *Explorer program*[17]. In the beginning, the participation was for developers only. Half a year later, the developers could invite two additional persons to the project. All together, there were up to 8,000 available pieces worldwide[18]. The third phase of the Explorer program, the public sales for US citizens older than 18 years, started on April, 15th 2014. 24th of June 2014, Glass was sold beyond the United States the first time. Until October 2014, more than 70,000 products were sold altogether[19].

The sales of Glass was stopped in January 2015[20], a planned cessation according to *Google [X]’s* CEO Astro Teller and Google’s CEO Eric Schmidt, because it has been a development project with related market activities, to get feedback and to improve the device[21]. However, by this time there was lot of criticism:

- The data goggle is seen with approximately 1,500 US Dollars as too expensive.
- The battery capacity is too low.
- The development is not mature and prone to error.
- Furthermore, the design is perceived as clunky and people criticized the wearing comfort additionally to normal glasses.

According to Google, the project will be restarted in a modified environment. For this purpose, it has been removed from the department *Google [X]* and it will be more ore less newly developed in its own subsidiary[22]. Version 2.0 should be designed primarily for the usage in industrial scenarios and within the healthcare industry and the price is reduced to 400 to 600 US Dollars[23]. Version 2.0 is developed in collaboration with Luxottica, an Italian eyewear

[15] Ibidem, p. 3.
[16] Ibidem, p. 4.
[17] wearvision (o. J. a) Google Glass, http://www.wearvision.de/googleglass/, 03.06.2015.
[18] wearvision (o. J. b) Google Glass: Explorer-Programm, http://www.wearvision.de/explorer-programm/, 03.06.2015.
[19] wearvision (o. J. c) Google Glass: Nach Google[X], http://www.wearvision.de/2015/01/ 20/leben-nach-google-x/, 03.06.2015.
[20] Google Inc.: We’re graduating from Google[x] labs It’s hard to believe that Glass started…, https://plus.google.com/+GoogleGlass/posts/9uiwXY42tvc, 03.06.2015.
[21] Barr A.: Google Isn’t Giving Up on Glass, Eric Schmidt Says, http://blogs.wsj.com/ digits/2015/03/23/google-isnt-giving-up-on-glass-schmidt-says/, 3 June 2015; Becker L.: Google X-Chef 'Astro Teller' über Glass, http://www.wearvision.de/2015/03/ 18/google-x-chef-astro-teller-ueber-glass/, 3 June 2015.
[22] Google Inc.: op.cit.
[23] wearvision (o. J. a)…, op.cit.

manufacturers, and Intel Corp.[24]. Based on recently registered patents from Google, published by the US Patent Office, it can be concluded that both, Glass 2.0 hardware and software technology is revised substantially[25].

From a technical perspective, the glass prism overlays informations in the visual field of users. It is a realization of *augmented reality,* so that environment information, websites, etc. can be directly displayed in the field of vision. Glass can be controlled via voice, head movements, or touch pad, which is located on the bracket (wearvision, o. J. a). The device itself leads to advantages like immediate availability of equipment, execution of functions, or hand-free operations. So, it consists of: glass prism and microprojectors, microcomputer (1 GHz, Texas Instruments, 256 MB RAM, 16 GB flash memory), microphone, digital camera (5 MP photo, up to 720p), bone conduction loud speaker, bluetooth, WLAN, GPS, accerleration sensor, gyroscop, battery, touchpad, REST-interface[26].

The compulsory functions of Glass are depending on the installed and installable apps, so-called *Glassware*. A standard set-up is already available so that Glass works with no further add-ons using standard functions. For example, photo admissions and video recordings are preloaded. But it has to be noted that the Smartphone application *MyGlass* (available on Android and iOS) is always necessary to be able to configure the device. This app is essential to activate other functions, to connect Glass with a smartphone, to setup contacts, and to adapt Glass on itself[27]. Besides, an established connection with a smartphone is a core element, because it is used to connect with the Internet (hotspot functionality), which is needed by many apps as well as Glass' phone services. The *MyGlass* application brings, besides its configuration, already some additional apps like *Twitter, Facebook, New York Times, CNN, Google Now,* and *Path* along[28].

In general, there are two different types of Glassware: First, *immersion*, which can be compared to smartphone apps and can be opened and closed. Second, *Live Cards* that run in real time and are being updated constantly, running in the background, and are displayed in the Glass timeline[29]. The Glass timeline and LiveCard apps, in contrast to immersion apps, cannot be controlled by speech (and thus not over the *OkGlass menu*). They are controlled by using

[24] Hecking M.: Google Glass kommt zurück, http://www.manager-magazin.de/unternehmen/ it/google-glass-kommt-zurueck-a-1030897.html, 03.06.2015.

[25] Olsson M.I., Heinrich M.J., Kelly D., Lapetina J.: Patent: Wearable device with input and output structures. Google Inc. (US 2013/0044042 A1), http://pdfaiw.uspto.gov/42/2013/ 40/004/1.pdf, 03.06.2015; Olsson M.I., Heinrich M.J.: Patent: Wearable display device. Google Inc. (US D727,317 S), http://pdfpiw.uspto.gov/ 17/273/D07/1.pdf, 03.06.2015.

[26] Google Inc. (o. J. b): Tech specs: Google Glass Help, https://support.google.com/glass/ answer/3064128?hl=de, 03.06.2015.

[27] Google Inc. (o. J. a): op.cit.

[28] Miller P.: Google Glass apps: everything you can do right now, http://www.theverge.com/2013/5/20/ 4339446/google-glass-apps-everything-you-can-do-right-now, 27.05.2015.

[29] Selmanovic D.: A Tutorial for Aspiring Google Glass Developers: Building Your First Glass App, http://www.toptal.com/google-glass/building-your-first-glass-app-a-tutorial-for-aspiring-google-glass-developers, 27.05.2015.

the touch pad only, so windows or apps can be switched with a wipe. With a tap, the user can select these apps[30].

Due to the reason that there is no AppStore, Apps have to be downloaded and have to be installed manually[31]. Due to the availability of the Glass Development Kit (GDK), which is an add-on for the Android SDK, everybody is able to code apps for Glass. But this also means that the developer must have access to the device itself, because there is no simulator/emulator[32] available[33]. As Glass runs on a modified version of Android, the programming of apps is marginally different from the programming of apps for Android. This has the advantage that developers, who have already programmed for this operating system, do not have to switch to a competely new development environment. Only adjustments to the specific nature of the GDK are necessary[34].

2.3. Research Issue

Glass is a device that addresses cyber physical systems with mobile capabilities within Industry 4.0 challenges. The following research questions formulate perspectives to be able to structure and discuss the technology effects of the mobile technology Glass.

1. Does Glass allow a high flexibility due to a global data availability and official availability?
2. Does Glass increase the efficiency of the quality assurance regarding to enlarged documentation possibilities of the technical equipment?
3. Does Glass increase the production effectiveness by its high mobility?
4. Can an increased transparency be guaranteed by an increased enterprise-wide interconnectedness?

[30] Miller P.: op.cit.
[31] Ibidem.
[32] Selmanovic D.: op.cit.; wearvision (o. J. a)…, op.cit.
[33] To show the application possibilities of Glass, an app selection will be enumerated in the following:
- *Augmedix* – A medical sector app for documenting patient suffering, which automatically transmits and processes the data into an electronic medical record.
- *Winky* – This app is not officially supported by Google and can be used only in debug mode. It allows you to take pictures by winks.
- *Real Time Translation* – This app translates signature in real time.
- *WatchMeTalk* – This app is helping hearing impaired or deaf people, by converting speech to text and displays it about Glass. The text has to be spoken in an app to smartphone.

[34] Wenderlich R.: Google Glass App Tutorial, http://www.raywenderlich.com/92840/google-glass-app-tutorial, 27.05.2015.

3. Mixed Method Approach

For the treatment of this research questions, Case Study Research (CSR) and Adoption Research are applied, in the latter case in particular the technology acceptance model (TAM). The mixed method approach is chosen, to gain a theoretical perspective at different levels on the usage of smart glasses. Therefore, this chapter discusses the suitability of CSR and TAM within our chosen approach.

3.1. Case Study Research

Case studies are used to get plausible information and tangible contents relative fast. Their results are based on a long-term experience of the participants. Case Study Research offers the academic procedure to gain knowledge out of case studies[35].

Robert K. Yin defines a case study as an empiric elevation and a radical analysis of a topically existing phenomenon within a real existing environment[36]. Whereby it is obvious that information in those environments are linked to individual experiences so that gained knowledge might be blurrerd between circumstances, real information, and the context[37].

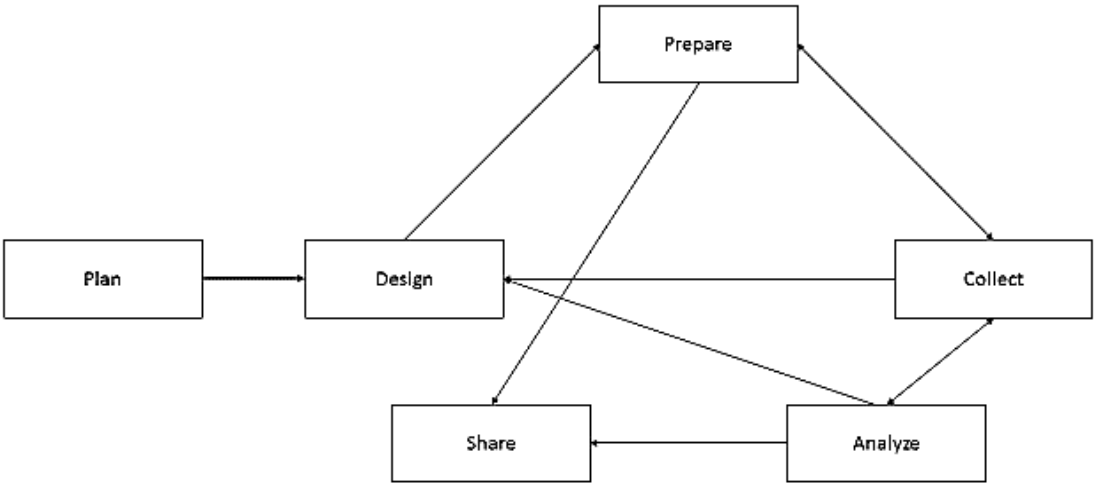

Fig. 1. Phases of Case Study Research; Yin R.K.: Case study research: Design and methods. Sage Publications Ltd., Los Angeles 2014.

Yin differenciats six phases of case study research: plan, design, prepare, collect data, analyse, and share a report (see fig. 1).

For the case study design, five directives are described. First, suitable research questions have to be stated to fix premises as well as to define analysis objects. The latter can describe individuals as well as communities. Likewise, logical associations between data and

[35] Yin R.K.: Case study research: Design and methods. Sage Publications Ltd., Los Angeles 2014, p. 5.
[36] Ibidem, p. 12.
[37] Ibidem.

propositions have to be placed. Ultimately, appropriate criteria for the interpretation of the results have to be set. Based on validity and reliability, the research structure's quality has to be examined. The validity of the construct is produced by utilizing multiple sources of evidence and a thorough review of the case study draft. The internal validity provides pattern matching or a time series analysis. By repeating-logic in multiple case studies, an external validity can be given. Finally, case study protocols and a case study database have to be developed to provide a comprehensive collection of raw data and aggregated data and to create a corresponding reliability of the examined statements[38].

As part of the phase *Prepare,* a case study protocol has to be written, too, which provides an overview about the project objectives, background, financing, involved people, subjects, relevant literature, research questions, propositions, and frame. In addition, the research questions and their basic information shall be recorded. Likewise, field procedures are included, such as contact persons, data protection, and the plan for data collection. It is also specified, in which form a case study report is to be made, for example, appearance and data format are set and the defined target group. In the following phase, the relevant data from different sources of evidence are collected. This may be documentaries, archival records (legacy), interviews, direct observations, participant observations, or artifacts like models or software etc.[39]. During the *analysis* phase different evaluation methods such as pattern matching, making argumentative statements, time series analysis, or the Cross Case Synthesis can be applied. Pattern Matching describes a pattern-based search, where discrete structures or subsets of such a structure can be identified by using a predefined pattern[40]. Time series analysis is a "process of decomposition of a time series into its components (time series components) based on a given empirical time series curve"[41]. A prognosis is the principal objective. The Cross Case Synthesis describes the comparison and integration of several case studies in the analysis. In the final case study phase, reporting plays a fundamental role. There are a variety of structures that are set in advance. Basic reports' content are an introduction, the current state of research, deployed case study design and results of the analysis, and a future outlook[42].

We have chosen Case Study Research, because it has been proven its suitability in several comparable research projects. For example, case studies were carried out to identify the implementation challenges of RFID chips as a new technology in existing industrial processes and their user benefits. One of the case studies has shown "the production of airbags studied in detail and analyzes it in terms of possible process improvements through the RFID technology"[43]. Furthermore, comparisons were made with existing technologies such as

[38] Ibidem, p. 5.
[39] Ibidem, p. 86.
[40] Cayrol M., Farreny H., Prade H.: Fuzzy Pattern Matching. "Kybernetes", Vol. 11(2), 1982, p. 103.
[41] Kamps U.: Zeitreihenanalyse, [in:] Gabler Wirtschaftslexikon, Springer Gabler Verlag (ed.), Online.
[42] Runeson P., Höst M.: Guidelines for conducting and reporting case study research in software engineering. "Empir. Software Eng", Vol. 14(2), 2009, p. 131-164.
[43] Ivantysynova L., Ziekow H.: RFID in der Produktion: Eine Fallstudie aus der Airbagindustrie. Der 37. Jahrestagung der Gesellschaft für Informatik e.V. (GI), 24.-27. September 2007 in Bremen, [in:] Koschke R.,

scanning devices and thus corresponding benefits and challenges to RFID chips could be analyzed. Potentials of RFID chips for a company could be demonstrated in detail and therefore "directly quantifiable savings [and] value adding by the use of RFID technology in a number of organizations in the value chain"[44]. The investigation has shown that case studies are useful to identify and discuss impacts while introducing new technologies. This method seems to be appropriate to gain insights into the changes originated by the introduction of new technologies.

3.2. Adoption Research

Within the scope of adoption research method comparisons, effects of the use of technology are to be examined[45]. This method offers a quick and better argumentation base than other methods. For the description of technology adoption criteria, the Technology Acceptance Model (TAM) is conceivable, because it is easy and fast in its use. It is often used in practice and is confirmed in different studies[46]. TAM describes that a new technology is adopted when it is useful and simple in its applicability[47] so the user has the intention to use the technology (fig. 2).

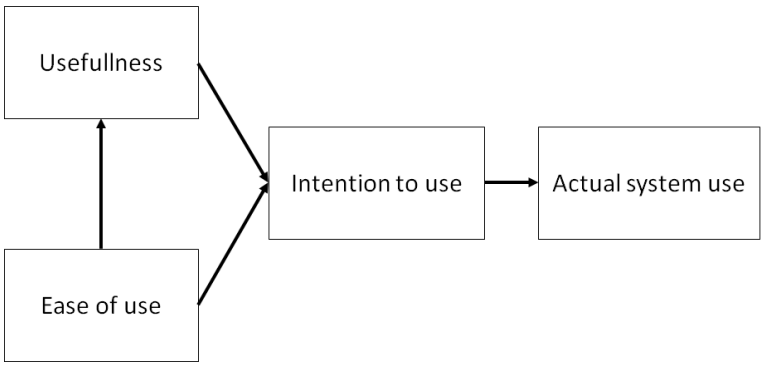

Fig. 2. Technology Acceptance Model; Davis F.D.: A Technology Acceptance Model for Empirically Testing New End-user Information Systems: Theory and Results. Thesis (Ph.D.), Sloan School of Management, 1985.

The theory elements *Ease of Use* and *Usefullness* describe the effect of a technology. Of course, this is a user's personal perception and can be seen differently. Besides, *Ease of Use* also moderates *Usefullness* and due to this the perceived benefit[48]. A huge number of opinions influences the result while getting a comprehensive picture. Also, the technology itself should

Herzog O., Rödiger K.-H., Ronthaler M. (eds.): INFORMATIK 2007: Informatik trifft Logistik. Band 1. Beiträge der 37. Jahrestagung der Gesellschaft für Informatik e.V. (GI), 24.-27. September 2007 in Bremen. GI, p. 95.

[44] Ibidem, p. 98.

[45] Davis F.D.: A Technology Acceptance Model for Empirically Testing New End-user Information Systems: Theory and Results. Thesis (Ph.D.), Sloan School of Management, 1985.

[46] King W.R., He J.: A meta-analysis of the technology acceptance model. "Information & Management", Vol. 43(6), 2006, p. 740-755.

[47] Davis F.D.: op.cit., p. 24.

[48] Ibidem, p. 26.

bring an increased use with it. This criterion can be assessed objectively, because it has to be seen as task-oriented. Likewise, the tool should be able to support the appropriate task performance or to solve a given problem. If one of the components is fulfilled, more and more users will use the technology and derive benefits from it. This means that the intention to use the technology increases and due to this that the adoption proceed positively[49].

The results of a study of W.R. King and J. He have shown that TAM, as a valid and robust method, is used and very often and demonstrates suitability to gain insights into a technology adoption process[50]. Legris, Ingham, and Collerette indicate that TAM can serve to understand and explain the adoption behaviour associated with technical systems and tools[51]. In addition, reliable statistical results and a raised quality were proved by this method, too[52].This makes the method suitable for the application in the course of the analysis of the usage scenarios of Glass.

4. Results Smart PLS

This chapter shows the results of the application of the Technology Acceptance Model by using the tool *SmartPLS*. For evaluation purposes and to gain better insights, the interviewees were subdivided into the groups of owners, employees, and other. In the following the results are shown in suitable tables. Detailled tables are put in the appendix so that this chapter is just showing the testing of the hypothesis only.

Hypotheses regarding Owner

Table 1

Path coeffitions – Owner

path coeffitions	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**
Effort Expectancy → Intention to adopt	0,0152	0,0166	0,0653	0,0653	0,2327
Performance Expectancy → Intention to adopt	0,7128	0,7111	0,0838	0,0838	**8,501**
Social Influence → Intention to adopt	0,2067	0,2092	0,1011	0,1011	**2,0437**
Top Management Leadership → Intention to adopt	0,0083	0,0103	0,0616	0,0616	0,1345

[49] Ibidem.
[50] King W.R., He J.: op.cit., p. 740.
[51] Legris P., Ingham J., Collerette P.: Why do people use information technology? A critical review of the technology acceptance model. "Information & Management", Vol. 40, 2003, p. 203.
[52] Ibidem, p. 204.

Table 2

Construct Crossvalidaded Redundancy – Owner

Construct Crossvalidaded Redundancy – Total	SSO	SSE	1-SSE/SSO
Intention to adopt	176	113,6549	0,3542

Hypotheses regarding Employees

Table 3

Path coeffitions – Employee

Path Coeffitions	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
Effort Expectancy → Intention to adopt	-0,0333	-0,0416	0,1559	0,1559	0,2133
Performance Expectancy → Intention to adopt	0,4648	0,4688	0,1352	0,1352	**3,4385**
Social Influence → Intention to adopt	0,2034	0,2048	0,1518	0,1518	1,3397
Top Management Leadership → Intention to adopt	0,1571	0,166	0,1166	0,1166	1,347

Table 4

Construct crossvalidaded redundancy – Employee

Construct Crossvalidaded Redundancy – Total	SSO	SSE	1-SSE/SSO
Intention to adopt	632	460,5661	0,2713

Hypotheses regarding Other

Table 5

Path Coeffitions – Other

Path Coeffitions	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
Effort Expectancy → Intention to adopt	0,0591	0,072	0,1523	0,1523	0,3877
Performance Expectancy → Intention to adopt	0,8038	0,7972	0,0785	0,0785	**10,2344**
Social Influence → Intention to adopt	-0,0021	-0,0019	0,1535	0,1535	0,0135
Top Management Leadership → Intention to adopt	0,0564	0,0513	0,0425	0,0425	1,3267

Table 6

Construct crossvalidaded redundancy – Other

Construct Crossvalidaded Redundancy – Total	SSO	SSE	1-SSE/SSO
Intention to adopt	136	70,9508	0,4783

4. Evaluation of Results

Within the scope of analyzing the effects of the basic conditions, the expectations regarding possible achievements and its related efforts, the social influence as well as the top management leadership are going to be examined for the intention to use smart glasses.

4.1. Evaluation of Group Owners

In case of the group *owners* as well as *employees* and *other* it can be stated that the general set-up has no significance for the possible adoption of the glasses. Therefore, it seems to be unimportant whether an enterprise has already experminented with the development of suitable applications for smart glasses or whether organizational barriers for implementing and potential use of smart glasses exist. However, a special influence on the intention of use effects the achievement expectation as well as the social influence. Smart glasses have to be seen as a useful user interface and should show an actual and quick possibility to be able to make qualitatively improved decisions. Additionally, it seems to be significant, how applicabel other companies and people evaluate the use of smart glasses. This also becomes supported by statements of representatives of BMW Manufacturing Co. LLC[53]. Therefore, they are aware about the fact that competitors, like VW, Mercedes etc., also evaluate usage scenarios for data goggles. However, BMW itself would like to be perceived as innovatively leading (company philosophy), which is the reason why using smart glasses was also suggested by the top management. Thus, the decision of a possible implementation was decisively influenced from outside. Statements of Wittenstein AG[54] support the hypothesis that the social impact is of great importance for the intention of use, even though in a different way. As expected, it is rather irrelevant in the industry that Wittenstein evaluated the technique together with the research institute DFKI. Therefore, the business value is not given or can be also achieved by using tablets. That is the reason why there is no follow up technology of smart glasses in the example of Wittenstein AG.

Within the SmartPLS evaluation, the impact of effort expectation is rather low. This is supported partially by the statements of BMW Manufacturing Co. LLC, because due to the raising expenses, another intensive development of such a technology is questionable. Nevertheless, they are aware that a disuse of data glasses could mean a possible step backward. In the context of a business flexibility, it is increasingly important to transmit information in a performant and goal-oriented manner to the respective employees vice versa. Also the influence of top management leadership seems to be less considerably. Therefore, the values and possible optimistic and enthusiastic attitudes of the person whom supports itself for the use

[53] Based on an interview with Dr. Jörg Schulte, Manager Liaison Office, Research and Innovation.
[54] Based on an interview with Dr. Jochen Schlick, Director Zukunftsfeld Cyber-Physische Systeme.

of the smart glass technology will have a lower role, if it comes to an increased intension to adopt or not.

4.2. Evaluation of Group Employees

Within the scope of the *employees* it is remarkable that exclusively the performance and development of achievements play an important role for the *intention of utilization*. Therefore, an easy and actual application of the technology is important. This is also reflected by statements of BMW Manufacturing Co. LLC and Wittenstein AG. The use of smartglasses, in particular wearing the glasses, is felt as unpleasant. In the example of Wittenstein, no especially positive impact while using it was felt by the employees. This also in comparison to other technologies. This is one reason, why the technology is not accepted in practice. At BMW Manufacturing Co. LLC potentials are perceptible, however, the practical use also is perceived as problematic here. The speech recognition is has to be iproved, because dialects or accents are not recognised and also the work in loud environments is difficulty. Also for example, Google's glass are merely controlled by speech recognition, because otherwise no tool activities and processes can be activated. The remaining potentials of influence on the intention of utilisation of Smart Glasses seems to be rather irrelevant in the area of the employees. This is explained by the fact that the users have concerns while using such a technology.

4.3. Evaluation of Group Others

The group *others* shows very similar results compared to the already introduced groups. Therefore, the performance and achievement expectation is for the *intention of utilisation* of data glasses of high relevance, too. The areas of *social influence*, *effort expectation* as well as *top management leadership* are playing only a minor part.

4.4. As Matters Stand

It is shown that the use of smart glasses offers a high potential and can also gain advantages compared to alternative technologies. In the example of BMW Manufacturing Co. LLC, potentials are seen particularly in the field of quality assurance. The task description includes to reach a faster identification of quality defects so that more effective decisions about possible quality measures can be made. The usage scenario includes the documentation of errors by using the posibilities of the data glasses (video, language) to allow an acceleration of quality indicators. For this purpose, a suitable app was developed and tested at the production site. This app has to synchronize data with the smartphone so that data are also transferred directly to a server to have them available. However, the question remains in context of technical implementation, which backend systems are necessary to support the workflow accordingly. In this example, a productive use of the glasses is not possible, yet, due to the performance of the technology. The battery runtime is too low and the heat generation of glasses is too high.

It makes sense to wait another two or three tool generations to get an adequate device. But nevertheless, the interest in the technology itself is high.

Wearing the glasses is, in case of BMW, not perceived as a problem, because there is already a need for protective glasses for the employees so that the device is just an add-on. It is rather the question, whether the comfort can be improved or an integration in the protective glasses is possible. Instead, in the example of Wittenstein AG, wearing the glasses is felt as uncomfortable and leads to no interest in using them. Additionally, company stakeholders do not show any interest for such a technology. This shows the high influence of the use and achievement expectation of the data glasses as well as the social influence.

5. Conclusions

The technology of smart glasses, especially the wearing and using comfort is improveable. But anyway, Glass is an innovation with a high potential with the demand to improve handling and practical application. Replying to our proposed research questions leads to the following conclusions:

1. Do Smart Glasses allow a high flexibility on account of a global data availability and official availability?

   From the technical point of view, data goggles offer a rising flexibility of the data availability and services, because it is applicable everywhere at any time. However, low battery terms and an often criticised heating of the glasses are a huge obstacle. This leads to the fact that in the given example of Glass, having them in use is limited to a maximum of 90 minutes. If this concern is improved, users see benefits of the data goggles. But, suitable applications for the specific usage scenarios have still to be developed. Thus the acceptance depends on usability and apps, because both are not efficient enough according to their actual performance. Nevertheless, this will presumably change with improved versions of the smart glasses and lead to a more practicable and comfortable use.
2. Does Glass increase the efficiency of the quality assurance with regard to enlarged documentation possibilities by the technical equipment?

   Based on the shown implementation, no appreciable efficiency of the quality assurance can be ascertained currently regarding documentation possibilities. It seems to be quite conceivable in further developments of the glasses that a long-term and an easy use is necessary. So, companies have no difficulties developing any corresponding applications either to increase their quality by using data goggles or improving their efficieny. It was also shown that decisions are mainly made because of performance

issues, because they are the basis for an argumentation against the implementation of smart glasses. So, challenging is still the performance improvement.

3. Does Glass increase the production effectiveness by his high mobility?
   A supported rising production effectiveness is currently not possible based on a high mobility, because the present performance of the data glasses do not offer increased mobility due to its limited battery capacity. However, this is mainly a technical problem, which has to be eliminated in the future. It is doubtful whether the data glasses will offer a raised advantage to alternative (mobile) technologies. The results of the survey make one suspect that it depends on the industry. Accordingly, decisions are influenced by external social influence. This could be seen as a results of the survey as well as of the interviews. In the example for BMW Manufacturies Co. it plays an absolutely critical role to deal with the introduction and utilization due to competitors. No confirmation came from Wittenstein AG, because the competitors and other stakeholders do not show particular interest on the use of smart glasses.
4. Can a high transparency be guaranteed by the high interlinking within enterprises?
   Especially top management representatives or managers still recognise a certain potential of the device. Based on developed applications, a simultaneous transmission of data is possible. The BMW Manufacturing Co. announced that it developed an app improving the quality especially of videos. This software allows a loop of two minutes (in the background) so that the appearance of errors or certain issues can better be identified without searching within a video. Besides, the data glasses synchronise itself with a smartphone so the data are available decentralized. This offers on the one hand a raised quality assurance, on the other hand a quicker and more efficient linking of data to support for example a production and quality assurance. A raised transparency occurs based on this interlinking. This can improve production effectiveness in the long term, because error recognition can be done early in the process.

Therefore and to sum up, it appears that an advancement of the present smart glasses show an absolutely attractive technology for technically affine areas. Currently, the weakness of the intention of utilisation is primarily in the performance and handling. It also shows in some industrie that the use of data goggles, because of social influences, is currently hardly to accept. Therefore, improvements of coming generations of the smart glasses have to be watched. Further research should address tool usablilty on the one hand side and usage scenarios on the other hand side to drive the development of this Industry 4.0 relevant technology.

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Appendix Results Smart PLS

This appendix shows the results of the application of the Technology Acceptance Model by using the tool Smart PLS. For evaluation purposes and to gain better insights, the interviewees were subdivided into the groups of owners, employees, and other. In the following the results are shown in suitable tables.

A.1. Results of the Group Owners

A.1.1. Reflective Constructs

First of all has to be noted that in the area of the owners the construct of *Faciliting Conditions* is cancelled, because of a too low significance. Also, the indicators 25 (*I believe that learning to use the system for Smart Glasses as user interface would have been easily. (Effort Expectancy)*) and 26 (*The top management of our company was helpful in making the decision about adopting Smart Glasses. (Social Influence)*) are cancelled, due to a too low indicator reliability. All remaining constructs and indicators could be maintained.

Table 7

Bootstrapping – Owner

Bootstrapping Owner	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**
Performance Expectancy					
18. At our company, I think we would have found that Smart Glasses is useful as user interface.	0,8657	0,8637	0,0312	0,0312	27,7867
19. Using Smart Glasses at our company as user interface would have been a more effective way to produce decisions.	0,9598	0,9594	0,0093	0,0093	103,0347
20. Using Smart Glasses at our company as user interface would have improved the quality of decision making.	0,9284	0,9285	0,0124	0,0124	74,9911
21. [Using Smart Glasses at our company as user interface would have enabled my company to make decision making more quickly.	0,931	0,9308	0,0112	0,0112	83,4214
Effort Expectancy					
22. I think that our company would have found the system that reports using Smart Glasses is clear and understandable.	0,9338	0,9383	0,0283	0,0283	33,0368
23. It would have been easy for our company to become skillful at using the system that uses Smart Glasses as user interface.	0,6912	0,6691	0,1179	0,1179	5,8644
24. I believe that our company would have found the system for Smart Glasses as user interface easy to use.	0,7934	0,7706	0,1057	0,1057	7,5039

cont. table 7

Social Influence					
27. In general, our company supported the adoption of Smart Glasses.	0,7711	0,7663	0,0553	0,0553	13,9466
28. Other firms and/or people who typically influence our company's actions think that my firm should have adopted Smart Glasses.	0,9723	0,9729	0,0047	0,0047	205,5625
29. Other firms and/or people who are important to our company believe that our company should have adopted Smart Glasses.	0,9723	0,9729	0,0047	0,0047	205,5625
Top Management Leadership					
30. The person in our company who was pushing for adopting Smart Glasses is someone who leads by talking about his/her most important values and beliefs.	0,9421	0,9419	0,0172	0,0172	54,7113
31. The person in our company who was pushing for adopting Smart Glasses is someone who displays a sense of power and confidence.	0,9859	0,986	0,003	0,003	332,6805
32. The person in our company who was pushing for adopting Smart Glasses is someone who always specifies the importance of having a strong sense of purpose.	0,9751	0,9753	0,0065	0,0065	149,1574
33. The person in our company who was pushing for adopting Smart Glasses is someone who emphasizes the importance of having a collective sense of mission.	0,9659	0,9666	0,0051	0,0051	188,8432
34. The person in our company who was pushing for adopting Smart Glasses is someone who talks enthusiastically about what needs to be accomplished.	0,9694	0,9694	0,0095	0,0095	102,0309
35. The person in our company who was pushing for adopting Smart Glasses is someone who talks optimistically about the future.	0,9826	0,983	0,0038	0,0038	260,1621
36. The person in our company who was pushing for adopting Smart Glasses is someone who articulates a compelling view of the future.	0,9862	0,9862	0,0029	0,0029	344,3447
37. The person in our company who was pushing for adopting Smart Glasses is someone who expresses confidence that goals will be achieved.	0,9826	0,983	0,0038	0,0038	260,1621

Table 8

Overview – Quality Criteria Owner

Overview	**AVE**	**Composite Reliability**	**R Square**	**Cronbachs Alpha**	**Communality**	**Redundancy**
Effort Expectancy	0,6597	0,8514	0	0,8312	0,6597	0
Performance Expectancy	0,8499	0,9577	0	0,9409	0,8499	0
Social Influence	0,8284	0,9347	0	0,8921	0,8284	0
Top Management Leadership	0,9483	0,9932	0	0,9922	0,9483	0

Table 9

Latent variable correlations – Owner

latent variable correlations	**Effort Expectancy**	**Intention to adopt**	**Performance Expectancy**	**Social Influence**	**Top Management Leadership**
Effort Expectancy	1	0	0	0	0
Intention to adopt	0,6288	1	0	0	0
Performance Expectancy	0,6813	0,8705	1	0	0
Social Influence	0,5909	0,7143	0,693	1	0
Top Management Leadership	0,7134	0,4962	0,5034	0,5721	1

Table 10

Cross Loadings reflekctive Constructs – Owner

Cross Loadings	**Effort Expec -tancy**	**Perfor-mance Expec-tancy**	**Social Influence**	**Top Manage-ment Leader-ship**
18. At our company, I think we would have found that Smart Glasses is useful as user interface.	0,4803	0,8657	0,5322	0,2733
19. At our company as user interface would have been a more effective way to produce decisions.	0,7535	0,9598	0,6967	0,5691
20. Using Smart Glasses at our company as user interface would have improved the quality of decision making.	0,6472	0,9284	0,7356	0,5022
21. Using Smart Glasses at our company as user interface would have enabled my company to make decision making more quickly.	0,6071	0,931	0,5664	0,4824
22. I think that our company would have found the system that reports using Smart Glasses is clear and understandable.	0,9338	0,791	0,681	0,6667
23. It would have been easy for our company to become skillful at using the system that uses Smart Glasses as user interface.	0,6912	0,2029	0,2114	0,5641
24. I believe that our company would have found the system for Smart Glasses as user interface easy to use.	0,7934	0,2615	0,2195	0,5202
27. In general, our company supported the adoption of Smart Glasses.	0,6714	0,5399	***0,7711***	**0,8521**
28. Other firms and/or people who typically influence our company's actions think that my firm should have adopted Smart Glasses.	0,4953	0,6718	**0,9723**	0,4053
29. Other firms and/or people who are important to our company believe that our company should have adopted Smart Glasses.	0,4953	0,6718	**0,9723**	0,4053
30. The person in our company who was pushing for adopting Smart Glasses is someone who leads by talking about his/her most important values and beliefs.	0,5251	0,3293	0,4808	**0,9421**
31. The person in our company who was pushing for adopting Smart Glasses is someone who displays a sense of power and confidence.	0,6545	0,526	0,6082	**0,9859**
32. The person in our company who was pushing for adopting Smart Glasses is someone who always specifies the importance of having a strong sense of purpose.	0,6919	0,4895	0,614	**0,9751**
33. The person in our company who was pushing for adopting Smart Glasses is someone who emphasizes the importance of having a collective sense of mission.	0,7442	0,5863	0,5959	**0,9659**

cont. table 10

34. The person in our company who was pushing for adopting Smart Glasses is someone who talks enthusiastically about what needs to be accomplished.	0,6695	0,4358	0,4469	**0,9694**
35. The person in our company who was pushing for adopting Smart Glasses is someone who talks optimistically about the future.	0,7581	0,5161	0,5876	**0,9826**
36. The person in our company who was pushing for adopting Smart Glasses is someone who articulates a compelling view of the future.	0,7223	0,4721	0,5028	**0,9862**
37. The person in our company who was pushing for adopting Smart Glasses is someone who expresses confidence that goals will be achieved.	0,7581	0,5161	0,5876	**0,9826**

Table 11

Blindfolding reflective Constructs – Owner

Blindfolding	**SSO**	**SSE**	**1-SSE/SSO**
Effort Expectancy	66	22,6956	0,6561
Performance Expectancy	88	14,3246	0,8372
Social Influence	66	10,6385	0,8388
Top Management Leadership	176	10,468	0,9405

A.1.2 Formative Constructs

Table 12

Outer Loadings – Owner

Outer Loadings	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**
1. My company intends to adopt Smart Glasses.	0,8215	0,823	0,0211	0,0211	38,9466
2. It is likely that my company will take some steps to adopt Smart Glasses in the future.	0,9047	0,9048	0,0186	0,0186	48,5178
3. We are evaluating the pros and cons of adopting Smart Glasses.	0,6127	0,6062	0,0708	0,0708	8,6478
4. We are testing whether or not to use Smart Glasses.	0,7735	0,7727	0,045	0,045	17,1712
5. We have Smart Glasses technology, but we are still evaluating pros and cons of its use.	0,6984	0,6951	0,0662	0,0662	10,5528
6. Using Smart Glasses is still NOT our normal tool as user interface.	-0,5011	-0,5021	0,0908	0,0908	5,5204
7. My company is using Smart Glasses as user interface.	0,5832	0,5765	0,0826	0,0826	7,0615
8. At my company, using Smart Glasses is now our normal procedure as user interface.	0,5917	0,5897	0,0735	0,0735	8,0494

Table 13

Outer Weights – Owner

Outer Weights	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
1. My company intends to adopt Smart Glasses.	0,257	0,2551	0,0192	0,0192	13,3897
2. It is likely that my company will take some steps to adopt Smart Glasses in the future.	0,2717	0,2698	0,0197	0,0197	13,7737
3. We are evaluating the pros and cons of adopting Smart Glasses.	0,1324	0,1319	0,0205	0,0205	6,4624
4. We are testing whether or not to use Smart Glasses.	0,2066	0,2052	0,0144	0,0144	14,3453
5. We have Smart Glasses technology, but we are still evaluating pros and cons of its use.	0,1407	0,1402	0,0184	0,0184	7,6358
6. Using Smart Glasses is still NOT our normal tool as user interface.	-0,153	-0,1525	0,0295	0,0295	5,1856
7. My company is using Smart Glasses as user interface.	0,1048	0,1034	0,0179	0,0179	5,8411
8. At my company, using Smart Glasses is now our normal procedure as user interface.	0,1118	0,1122	0,0139	0,0139	8,0331

A.2 Results for Group *Employees*

A.2.1 Reflective Constructs

Table 14

Bootstrapping – Employee

Bootstrapping – Employee	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
Performance Expectancy					
18. At our company, I think we would have found that Smart Glasses is useful as user interface.	0,9099	0,9074	0,0198	0,0198	45,8625
19. Using Smart Glasses at our company as user interface would have been a more effective way to produce decisions.	0,9573	0,9568	0,0105	0,0105	91,0183
20. Using Smart Glasses at our company as user interface would have improved the quality of decision making.	0,9535	0,9537	0,0109	0,0109	87,8702
21. Using Smart Glasses at our company as user interface would have enabled my company to make decision making more quickly.	0,9099	0,9129	0,0376	0,0376	24,2089
Effort Expectancy					
22. I think that our company would have found the system that reports using Smart Glasses is clear and understandable.	0,8924	0,8911	0,0186	0,0186	48,0529
23. It would have been easy for our company to become skillful at using the system that uses Smart Glasses as user interface.	0,9332	0,9274	0,0191	0,0191	48,925

cont. table 14

24. I believe that our company would have found the system for Smart Glasses as user interface easy to use.	0,9319	0,9305	0,0166	0,0166	56,0322
25. I believe that learning to use the system for Smart Glasses as user interface would have been easy.	0,7018	0,6921	0,0792	0,0792	8,8655
Social Influence					
26. The senior management of our company was helpful in making the decision about adopting Smart Glasses.	0,8038	0,7945	0,0566	0,0566	14,2116
27. In general, our company supported the adoption of Smart Glasses.	0,9161	0,9143	0,0202	0,0202	45,3958
28. Other firms and/or people who typically influence our company's actions think that my firm should have adopted Smart Glasses.	0,9342	0,9332	0,0146	0,0146	63,9278
29. Other firms and/or people who are important to our company believe that our company should have adopted Smart Glasses.	0,9495	0,95	0,0101	0,0101	93,818
Top Management Leadership					
30. The person in our company who was pushing for adopting Smart Glasses is someone who leads by talking about his/her most important values and beliefs.	0,9575	0,9575	0,0148	0,0148	64,8686
31. The person in our company who was pushing for adopting Smart Glasses is someone who displays a sense of power and confidence.	0,9657	0,964	0,0132	0,0132	73,2343
32. The person in our company who was pushing for adopting Smart Glasses is someone who always specifies the importance of having a strong sense of purpose.	0,9733	0,9726	0,01	0,01	97,3464
33. The person in our company who was pushing for adopting Smart Glasses is someone who emphasizes the importance of having a collective sense of mission.	0,9435	0,9411	0,0182	0,0182	51,8114
34. The person in our company who was pushing for adopting Smart Glasses is someone who talks enthusiastically about what needs to be accomplished.	0,8989	0,892	0,0394	0,0394	22,8337
35. The person in our company who was pushing for adopting Smart Glasses is someone who talks optimistically about the future.	0,9655	0,9642	0,0129	0,0129	74,5967
36. The person in our company who was pushing for adopting Smart Glasses is someone who articulates a compelling view of the future.	0,9802	0,9805	0,0058	0,0058	169,4559
37. The person in our company who was pushing for adopting Smart Glasses is someone who expresses confidence that goals will be achieved.	0,9645	0,964	0,0109	0,0109	88,8277

Table 15

Overview – Quality Criteria – Employee

Overview	AVE	Composite Reliability	R Square	Cronbachs Alpha	Communality	Redundancy
Effort Expectancy	0,757	0,9249	0	0,8911	0,757	0
Performance Expectancy	0,8703	0,9641	0	0,9502	0,8703	0
Social Influence	0,815	0,9461	0	0,9238	0,815	0
Top Management Leadership	0,9147	0,9885	0	0,9866	0,9147	0

Table 16

Latent variable correlations – Employee

Latent variable Correlations	Effort Expectancy	Performance Expectancy	Social Influence	Top Management Leadership
Effort Expectancy	1	0	0	0
Performance Expectancy	0,7884	1	0	0
Social Influence	0,7157	0,6903	1	0
Top Management Leadership	0,605	0,6264	0,7597	1

Table 17

Cross Loadings – Employee

Cross Loadings	Effort Expect-ancy	Intent-ion to adopt	Perform-ance Expectancy	Social Influ-ence	Top Managemen t Leadership
18. At our company, I think we would have found that Smart Glasses is useful as user interface.	0,7893	0,6053	**0,9099**	0,6252	0,5392
19. Using Smart Glasses at our company as user interface would have been a more effective way to produce decisions.	0,7308	0,6678	**0,9573**	0,6201	0,5762
20. Using Smart Glasses at our company as user interface would have improved the quality of decision making.	0,7351	0,6619	**0,9535**	0,6531	0,6624
21. Using Smart Glasses at our company as user interface would have enabled my company to make decision making more quickly.	0,6893	0,588	**0,9099**	0,6832	0,555
22. I think that our company would have found the system that reports using Smart Glasses is clear and understandable.	**0,8924**	0,5905	0,7753	0,6796	0,6159
23. It would have been easy for our company to become skillful at using the system that uses Smart Glasses as user interface.	**0,9332**	0,47	0,652	0,6577	0,4915
24. I believe that our company would have found the system for Smart Glasses as user interface easy to use.	**0,9319**	0,5551	0,7114	0,6846	0,5417
25. I believe that learning to use the system for Smart Glasses as user interface would have been easy.	**0,7018**	0,3187	0,5846	0,4107	0,4301
26. The senior management of our company was helpful in making the decision about adopting Smart Glasses.	0,6635	0,4069	0,5487	**0,8038**	0,544

cont. table 17

27. In general, our company supported the adoption of Smart Glasses.	0,7477	0,6206	0,7413	**0,9161**	0,7382
28. Other firms and/or people who typically influence our company's actions think that my firm should have adopted Smart Glasses.	0,5916	0,6176	0,5871	**0,9342**	0,7136
29. Other firms and/or people who are important to our company believe that our company should have adopted Smart Glasses.	0,5975	0,5536	0,6026	**0,9495**	0,7186
30. The person in our company who was pushing for adopting Smart Glasses is someone who leads by talking about his/her most important values and beliefs.	0,59	0,6016	0,6332	0,7229	**0,9575**
31. The person in our company who was pushing for adopting Smart Glasses is someone who displays a sense of power and confidence.	0,536	0,5731	0,6018	0,7305	**0,9657**
32. The person in our company who was pushing for adopting Smart Glasses is someone who always specifies the importance of having a strong sense of purpose.	0,5822	0,5813	0,59	0,7503	**0,9733**
33. The person in our company who was pushing for adopting Smart Glasses is someone who emphasizes the importance of having a collective sense of mission.	0,5828	0,539	0,5885	0,7246	**0,9435**
34. The person in our company who was pushing for adopting Smart Glasses is someone who talks enthusiastically about what needs to be accomplished.	0,5392	0,4645	0,5362	0,7274	**0,8989**
35. The person in our company who was pushing for adopting Smart Glasses is someone who talks optimistically about the future.	0,607	0,5074	0,5769	0,732	**0,9655**
36. The person in our company who was pushing for adopting Smart Glasses is someone who articulates a compelling view of the future.	0,5786	0,568	0,617	0,7221	**0,9802**
37. The person in our company who was pushing for adopting Smart Glasses is someone who expresses confidence that goals will be achieved.	0,6125	0,5997	0,6367	0,7105	**0,9645**

Table 18

Blindfolding reflective constructs – Employee

Blindfolding – Total	**SSO**	**SSE**	**1-SSE/SSO**
Effort Expectancy	316	76,4153	0,7582
Performance Expectancy	316	47,7664	0,8488
Social Influence	316	57,7146	0,8174
Top Management Leadership	632	55,8709	0,9116

A.2.2 Formative Constructs

Table 19

Bootstrapping Outer Loadings – Employee

Bootstrapping Outer Loadings	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
1. My company intends to adopt Smart Glasses.	0,8997	0,9024	0,0182	0,0182	49,3946
2. It is likely that my company will take some steps to adopt Smart Glasses in the future.	0,7825	0,7827	0,0344	0,0344	22,7732
3. We are evaluating the pros and cons of adopting Smart Glasses.	0,8051	0,8051	0,0342	0,0342	23,541
4. We are testing whether or not to use Smart Glasses.	0,8942	0,8923	0,0288	0,0288	31,059
5. We have Smart Glasses technology, but we are still evaluating pros and cons of its use.	0,8369	0,832	0,0417	0,0417	20,0813
6. Using Smart Glasses is still NOT our normal tool as user interface.	-0,0603	-0,0571	0,1108	0,1108	0,5437
7. My company is using Smart Glasses as user interface.	0,8081	0,8003	0,0446	0,0446	18,1302
8. At my company, using Smart Glasses is now our normal procedure as user interface.	0,7371	0,7239	0,0676	0,0676	10,9056

Table 20

Bootstrapping Outer Weights – Employee

Bootstrapping Outer Weights	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
1. My company intends to adopt Smart Glasses.	0,2337	0,2353	0,0207	0,0207	11,2827
2. It is likely that my company will take some steps to adopt Smart Glasses in the future.	0,2182	0,2199	0,0245	0,0245	8,8994
3. We are evaluating the pros and cons of adopting Smart Glasses.	0,1883	0,1917	0,0174	0,0174	10,8337
4. We are testing whether or not to use Smart Glasses.	0,1658	0,1658	0,0095	0,0095	17,4268
5. We have Smart Glasses technology, but we are still evaluating pros and cons of its use.	0,1394	0,138	0,0111	0,0111	12,5943
6. Using Smart Glasses is still NOT our normal tool as user interface.	-0,0518	-0,0471	0,0358	0,0358	1,4477
7. My company is using Smart Glasses as user interface.	0,1397	0,1374	0,0121	0,0121	11,5388
8. At my company, using Smart Glasses is now our normal procedure as user interface.	0,1174	0,1151	0,0173	0,0173	6,7992

A.3 Results for Group Other

A.3.1 Reflective Constructs

In the group *Others*, the construct of the *Facilitating Conditions* has been deleted due to minor significance. All the other constructs and indicators are maintained.

Table 21

Bootstrapping – Ot her

Bootstrapping Other	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**
Performance Expectancy					
18. At our company, I think we would have found that Smart Glasses is useful as user interface.	0,9193	0,922	0,0096	0,0096	95,8346
19. Using Smart Glasses at our company as user interface would have been a more effective way to produce decisions.	0,9858	0,9861	0,0032	0,0032	308,4619
20. Using Smart Glasses at our company as user interface would have improved the quality of decision making.	0,988	0,9883	0,0019	0,0019	532,2628
21. Using Smart Glasses at our company as user interface would have enabled my company to make decision making more quickly.	0,7532	0,7559	0,0583	0,0583	12,9102
Effort Expectancy					
22. I think that our company would have found the system that reports using Smart Glasses is clear and understandable.	0,8992	0,9	0,0206	0,0206	43,5958
23. It would have been easy for our company to become skillful at using the system that uses Smart Glasses as user interface.	0,9484	0,9487	0,012	0,012	79,2731
24. I believe that our company would have found the system for Smart Glasses as user interface easy to use.	0,9518	0,9523	0,0114	0,0114	83,4418
25. I believe that learning to use the system for Smart Glasses as user interface would have been easy.	0,9632	0,9634	0,0076	0,0076	127,5071
Social Influence					
26. The senior management of our company was helpful in making the decision about adopting Smart Glasses.	0,9515	0,9519	0,0128	0,0128	74,3523
27. In general, our company supported the adoption of Smart Glasses.	0,9659	0,966	0,0124	0,0124	77,8954
28. Other firms and/or people who typically influence our company's actions think that my firm should have adopted Smart Glasses.	0,9134	0,9139	0,0261	0,0261	35,0107
29. Other firms and/or people who are important to our company believe that our company should have adopted Smart Glasses.	0,9539	0,9547	0,011	0,011	86,3574

cont. table 21

Top Management Leadership					
30. The person in our company who was pushing for adopting Smart Glasses is someone who leads by talking about his/her most important values and beliefs.	0,995	0,995	0,002	0,002	496,5814
31. The person in our company who was pushing for adopting Smart Glasses is someone who displays a sense of power and confidence.	0,9875	0,9876	0,0044	0,0044	223,6774
32. The person in our company who was pushing for adopting Smart Glasses is someone who always specifies the importance of having a strong sense of purpose.	0,995	0,995	0,002	0,002	496,5814
33. The person in our company who was pushing for adopting Smart Glasses is someone who emphasizes the importance of having a collective sense of mission.	0,9875	0,9876	0,0044	0,0044	223,6774
34. The person in our company who was pushing for adopting Smart Glasses is someone who talks enthusiastically about what needs to be accomplished.	0,9875	0,9876	0,0044	0,0044	223,6774
35. The person in our company who was pushing for adopting Smart Glasses is someone who talks optimistically about the future.	0,995	0,995	0,002	0,002	496,5814
36. The person in our company who was pushing for adopting Smart Glasses is someone who articulates a compelling view of the future.	0,995	0,995	0,002	0,002	496,5814
37. The person in our company who was pushing for adopting Smart Glasses is someone who expresses confidence that goals will be achieved.	0,995	0,995	0,002	0,002	496,5814

Table 22

Overview Other

Overview Other	**AVE**	**Composite Reliability**	**R Square**	**Cronbachs Alpha**	**Commu-nality**	**Redun-dancy**
Effort Expectancy	0,8855	0,9687	0	0,9567	0,8855	0
Intention to adopt	0,6358	0,9258	0,7922	0,8976	0,6358	0,0545
Performance Expectancy	0,8401	0,9541	0	0,9328	0,8401	0
Social Influence	0,8957	0,9717	0	0,961	0,8957	0
Top Management Leadership	0,9844	0,998	0	0,9977	0,9844	0

Table 23

Cross Loadings – Other

Cross Loadings	Effort Expect-ancy	Perfor-mance Expect-ancy	Social Influence	Top Manage-ment Leader-ship
18. At our company, I think we would have found that Smart Glasses is useful as user interface.	0,8401	**0,9193**	0,7083	0,5419
19. Using Smart Glasses at our company as user interface would have been a more effective way to produce decisions.	0,8277	**0,9858**	0,7519	0,6159
20. Using Smart Glasses at our company as user interface would have improved the quality of decision making.	0,7691	**0,988**	0,6822	0,5677
21. Using Smart Glasses at our company as user interface would have enabled my company to make decision making more quickly.	0,6231	**0,7532**	0,6535	0,6209
22. I think that our company would have found the system that reports using Smart Glasses is clear and understandable.	**0,8992**	0,7768	0,8766	0,8303
23. It would have been easy for our company to become skillful at using the system that uses Smart Glasses as user interface.	**0,9484**	0,7698	0,8925	0,6829
24. I believe that our company would have found the system for Smart Glasses as user interface easy to use.	**0,9518**	0,7664	0,891	0,6878
25. I believe that learning to use the system for Smart Glasses as user interface would have been easy.	**0,9632**	0,8387	0,8568	0,7679
26. The senior management of our company was helpful in making the decision about adopting Smart Glasses.	0,8962	0,6939	**0,9515**	0,7494
27. In general, our company supported the adoption of Smart Glasses.	0,9241	0,6786	**0,9659**	0,8174
28. Other firms and/or people who typically influence our company's actions think that my firm should have adopted Smart Glasses.	0,8545	0,711	**0,9134**	0,7637
29. Other firms and/or people who are important to our company believe that our company should have adopted Smart Glasses.	0,8627	0,7932	**0,9539**	0,6752
30. The person in our company who was pushing for adopting Smart Glasses is someone who leads by talking about his/her most important values and beliefs.	0,7888	0,6056	0,7844	**0,995**
31. The person in our company who was pushing for adopting Smart Glasses is someone who displays a sense of power and confidence.	0,78	0,6666	0,7918	**0,9875**
32. The person in our company who was pushing for adopting Smart Glasses is someone who always specifies the importance of having a strong sense of purpose.	0,7888	0,6056	0,7844	**0,995**
33. The person in our company who was pushing for adopting Smart Glasses is someone who emphasizes the importance of having a collective sense of mission.	0,78	0,6666	0,7918	**0,9875**
34. The person in our company who was pushing for adopting Smart Glasses is someone who talks enthusiastically about what needs to be accomplished.	0,78	0,6666	0,7918	**0,9875**
35. The person in our company who was pushing for adopting Smart Glasses is someone who talks optimistically about the future.	0,7888	0,6056	0,7844	**0,995**

cont. table 23

36. The person in our company who was pushing for adopting Smart Glasses is someone who articulates a compelling view of the future.	0,7888	0,6056	0,7844	**0,995**
37. The person in our company who was pushing for adopting Smart Glasses is someone who expresses confidence that goals will be achieved.	0,7888	0,6056	0,7844	**0,995**

Table 24

Blindfolding reflektiv – Other

Blindfolding Total	**SSO**	**SSE**	**1-SSE/SSO**
Effort Expectancy	68	8,0522	0,8816
Performance Expectancy	68	14,3584	0,7888
Social Influence	68	7,5164	0,8895
Top Management Leadership	136	3,206	0,9764

A.3.2 Formative Constructs

Table 25

Bootstrapping Outer Loadings – Other

Outer Loadings	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**
1. My company intends to adopt Smart Glasses.	0,9087	0,9096	0,023	0,023	39,4916
2. It is likely that my company will take some steps to adopt Smart Glasses in the future.	0,9433	0,9443	0,0088	0,0088	107,4876
3. We are evaluating the pros and cons of adopting Smart Glasses.	0,8457	0,8459	0,019	0,019	44,4103
4. We are testing whether or not to use Smart Glasses.	0,8744	0,8713	0,0261	0,0261	33,4372
5. We have Smart Glasses technology, but we are still evaluating pros and cons of its use.	0,9352	0,9343	0,0072	0,0072	130,2873
6. Using Smart Glasses is still NOT our normal tool as user interface.	0,1066	0,0799	0,1173	0,1173	0,9082
7. My company is using Smart Glasses as user interface.	0,7397	0,735	0,0681	0,0681	10,861
8. At my company, using Smart Glasses is now our normal procedure as user interface.	0,6769	0,6689	0,0698	0,0698	9,693

Table 26

Bootstrapping Outer Weights – Other

Outer Weights	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Standard Error (STERR)**	**T Statistics (|O/STERR|)**
1. My company intends to adopt Smart Glasses.	0,1819	0,1827	0,009	0,009	20,3106
2. It is likely that my company will take some steps to adopt Smart Glasses in the future.	0,1983	0,199	0,01	0,01	19,917
3. We are evaluating the pros and cons of adopting Smart Glasses.	0,2086	0,2083	0,0115	0,0115	18,0972

cont. table 26

4. We are testing whether or not to use Smart Glasses.	0,1764	0,1751	0,0071	0,0071	24,8555
5. We have Smart Glasses technology, but we are still evaluating pros and cons of its use.	0,1784	0,1782	0,0085	0,0085	20,9996
6. Using Smart Glasses is still NOT our normal tool as user interface.	0,0385	0,0331	0,0246	0,0246	1,5651
7. My company is using Smart Glasses as user interface.	0,1131	0,1123	0,0139	0,0139	8,1107
8. At my company, using Smart Glasses is now our normal procedure as user interface.	0,0923	0,0906	0,0156	0,0156	5,907

Table 27

Latent variable correlation – Other

latent variable correlation	**Effort Expectancy**	**Intention to adopt**	**Performance Expectancy**	**Social Influence**	**Top Management Leadership**
Effort Expectancy	1	0	0	0	0
Intention to adopt	0,7761	1	0	0	0
Performance Expectancy	0,8389	0,8875	1	0	0
Social Influence	0,9343	0,7096	0,7611	1	0
Top Management Leadership	0,7917	0,6113	0,6343	0,7936	1