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TAMPERE UNIVERSITY OF TECHNOLOGY

TUGBERK DUMAN

IDENTIFICATION OF PREMIUM PASSENGERS THROUGH SMART GLASS AND FACE RECOGNITION AT THE AIRPORT

Master of Science thesis

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ABSTRACT

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After mobile technologies became an integral part of daily life, the offering of services that utilize mobile platforms turned into a necessity for service providers. Companies were forced to either enhance their service offering with the mobile services or digitalize their current offering. Airport operators could not remain indifferent to that rapid advancement in the technology and added kiosk check-in, online check –in and mobile check- in starting from the early 2000s to any of their passenger. Nowadays, these services are provided in the same form, although technology kept evolving and the service needs of passenger started to vary with the introduction of loyalty programs. Airports and airlines took the latter into consideration and offered additional services to their premium passengers such as special check-in counter, premium lane at the security pass and priority at the boarding. Despite this, fiercer competition and increasing demand from the premium passengers calls for new differentiation methods. Using smart glasses combined with face recognition to provide boarding pass free travel would appeal to premium passengers' need to be distinguished. As an unprecedented endeavor, it would also be a key opportunity for an airport operator to differentiate itself in the aviation industry.

Previous studies on new service development mainly focused on B2B market where customer have an understanding of their needs and the technology. Face recognition at the airports has been featured in a handful research but the emphasis has always been on its contribution to airport and border security, hence, its application as a premium service is often overlooked. Therefore, this study explores the feasibility of face recognition and wearable technologies as an identification service for premium passengers.

New premium service has been designed, processes at the premium security pass point studied and user stories collected through the tests and interviews. After sourcing of the hardware and software needs completed in March, a proof of concept has been developed with an airport operator from Finland. Reliability of face recognition in terms of accuracy and robustness as an identification method was tested. The airline contribution was limited to airport operator's interpretation from the informal discussions that they have had. The passenger participation specifics were set aside as this thesis had no access to them during the thesis timeline. It is suggested that a future study is conducted using the smart glass application in the passenger context for further validation of the concept.

PREFACE

Through this study, I had the chance to be part of aviation industry in Finland. I was able to use my academic background, experiences in the field that I would like to pursue my career after graduation. Back in September, 2015, I had the idea of using cutting edge technologies to make a change in the way airports recognize their passengers. Now in August, 2016 we have a prototype that is able to turn the idea to reality in near future.

I am grateful for the guidance, support and feedback I received from my supervisors Samuli Pekkola and Kaisa Väänänen throughout the thesis. Special thanks go to, Eero Knuutila, Head of Service Development Department at Finavia, who facilitated this project and provided support whenever it was necessary. I would also like to thank all Finavia employees who made themselves available to help with the project in the times of need.

With this thesis, I am closing a chapter in my life. It has not been always easy, but I was lucky enough to have people that helped me stay strong and reach to the point where I am now. I can't possibly name them all, but I wholeheartedly thank to those who have supported me so far. I hope that they would stay with me in the next chapters of my life to come.

Helsinki, 23/08/2016

Tugberk Duman

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LIST OF SYMBOLS AND ABBREVIATIONS

ID	Identification
OYJ	Osakeyhtiö / Public Stock Company
IATA	International Air Transport Association
NSD	New Service Development
RFID	Radio Frequency Identification
SDK	Software Development Kit
UI	User Interface

1. INTRODUCTION

This chapter provides background information on the research and its scope. It also explains the motivation behind the research and provides insights on the need for it. Research objectives and the goals are discussed under the light of the background and motivation. The chapter ends with the illustration of the thesis structure.

1.1 Background and Motivation

Managements of airlines and airport operators initially thought of internet as a new platform to provided added value services and products in order to strengthen ties between carrier and the passenger. As mobile technologies became a commodity for common public, delivery of the services that run on mobile platforms also became a must for the service providers (Best, 2013). Over the last decade, the mobile capability has taken a new form, namely, wearables, due to rapidly advancing technology and ever growing enthusiasm towards them (Bryson & McCann, 2009).

Wearable technologies, first emerged in military research programs in late 90s, started to appear in the daily lives of general public (Bryson & McCann, 2009). Applications of wearable technology vary from physical medicine and rehabilitation to sports. For instance; according to Bonato (2005), wearable technology allows clinicians to gather data to observe if clinical interventions have an impact on real life patients. In sports, the wearable technologies are being used to promote fairness or enhance fan experience. An impact measurement system was developed in 2005, utilizing wearable sensors to assist judges in Martial Arts competitions (Chi, 2005). Nowadays, there is an accelerated transition from handheld technologies to the wearable ones as smart watches and smart glasses are on their way to become commodity. Aviation industry can no longer remain indifferent to this transition. Especially airports are receiving increasing demand from airlines and passengers to provide a seamless airport experience, at a cost that reflects the realities of modern aviation and technology (Best, 2013).

In the early stages of this transition, airports can use these technologies to enhance the experience of its premium passengers (i.e. frequent traveler card holders and business class passengers). The current technology at the airports is not capable of providing high-end services to the premium passengers. The current services for the premium passengers usually lack the notion of technology. An example could be Premium Lane Security Pass, where entry is only granted to premium passengers. Piloting the technology in this area before full adoption can test the technical feasibility, and can provide viable feedback regarding reaction of the common public.

Although wearable technology can provide many improvements itself, such as flexible infrastructure, and hands-free use, a complementary tool still needs to be used to outperform the current airport ID management technologies and to present an extraordinary value to the passengers and to the airport operators that are aiming to enhance the passenger experience. Face recognition is the new form of biometric systems. Biometric systems are being used by government-led initiatives such as electronic passports (e-passports) or national ID cards. The legal and social impact of biometric systems are increasing in our daily lives (Vilhauer et al., 2011). Therefore; it is important to address the current shortcomings of delivery of these systems and get ready for future applications (Vilhauer et al., 2011), in which biometrics are utilized to increase service quality rather than only serving as an additional measure in terms of security. By using wearable technology reinforced with the face recognition on the premium lane security pass, airport's ability to recognize its privileged passengers will be increased and the first steps for adopting future travelling experience will be taken.

This thesis explores new service development elements, particularly focusing on those enabled by the rapid advancement in the wearable technology. The phenomenon is studied by emphasizing process changes in ID management due to development of the new service. Technologies that will be used to materialize the idea are studied in two different levels - hardware and software. The compatibility of the face recognition with the designated choice of hardware is explained under the light of previous cases.

This thesis was done for Finavia OYJ, Finnish, state-owned, airport operator. It is considered as the first necessary step to materialize Future Passenger Experience Vision set by IATA in 2013.

1.2 Goals, Research Questions and Scope

The goal of this research project is to develop a proof of concept for smart glass combined with face recognition aiming to test the feasibility of the boarding pass free travel for the premium passengers. In the context of this research, boarding pass-free travel refers to airports' ability to recognize their passengers with face recognition at any checkpoint instead of identification through boarding pass or ID card. This goal is oriented towards a better understanding on how recognition of premium passengers in many airport operations including check-in, passport control, and boarding can be improved through the proposed service. Use of smart glass and face recognition as a premium service for premium passengers is studied from the perspective of airport operators without undermining the importance of the airline collaboration, considering the fact that target group consists of their customers.

This is considered to be first steps of future passenger experience envisioned by IATA in 2013. Future passenger experience aims to create an interactive communication network between the stakeholders of commercial aviation using latest technologies and the biometrics to enhance the passenger experience (Best, 2013). If the vision is materialized, paperwork such as boarding cards will become futile, and inconveniences such as several security controls at transfer destinations will be eliminated.

The realization of this vision could also be the solution for ever increasing need for additional security measures in air travel. The overall idea emphasizes the collaborative work of the airport operators and airlines to provide high level of service, while ensuring maximum security. The first step towards that vision could be adding smart glasses equipped with face recognition ability to the current infrastructure. Therefore, the main research question is…

> *How smart glasses, combined with face recognition, can be used to provide boarding pass free travel service for premium passengers?*

This new service to the premium passengers brings radical changes to the current identification method at the premium lane security pass point. The effects of the aforementioned changes will be seen in both passenger perspective and ground host/hostess perspective. The processes that a ground host/hostess follows to allow the passenger will be changed as well as the experience of the target group at premium lane security pass point. To complement the main research question the following sub-questions are raised…

- *How can this new service affect the current identification method (i.e. boarding pass) in premium lane security pass?*
- *What are the tasks of airport operators to materialize the objectives of the new service?*

The combination of wearable technologies and face recognition provides many possibilities to improve the service offering of airport operators. This thesis explores the perspectives of the airport operator, user (i.e. ground host/hostess) and premium passengers of the airlines in the context of security pass points at the airport. This study does emphasize the importance of the collaboration of the airlines, but airline point of view is not explained in depth as there is no direct access to them.

The scope of this study will be limited to premium lane security pass of the premium passengers. The test and implementation of the proposed service in the suggested areas are planned to be completed within the duration of the research. However, the prototype for the end-product will be tested with Finavia OYJ employees to observe the accuracy rate (i.e. percentage of the successfully recognized faces) before proceeding to test in the actual target group. Beside the premium lane security pass point, aforementioned areas are left as topics for further research.

1.3 Structure of the Thesis

Formats and regulations at Tampere University of Technology have been followed while structuring this thesis. The need and research objectives are made clear in Chapter 1. The second chapter presents a literature review that establishes the background information needed for the analysis of the empirical study in the light of the previous cases. The third chapter illustrates the path followed to research the present topic. The case is presented in the following with chapter and lessons learnt are presented in Chapter 5. The last chapter presents the conclusions of the thesis. More detailed information is presented in Figure 1 below.

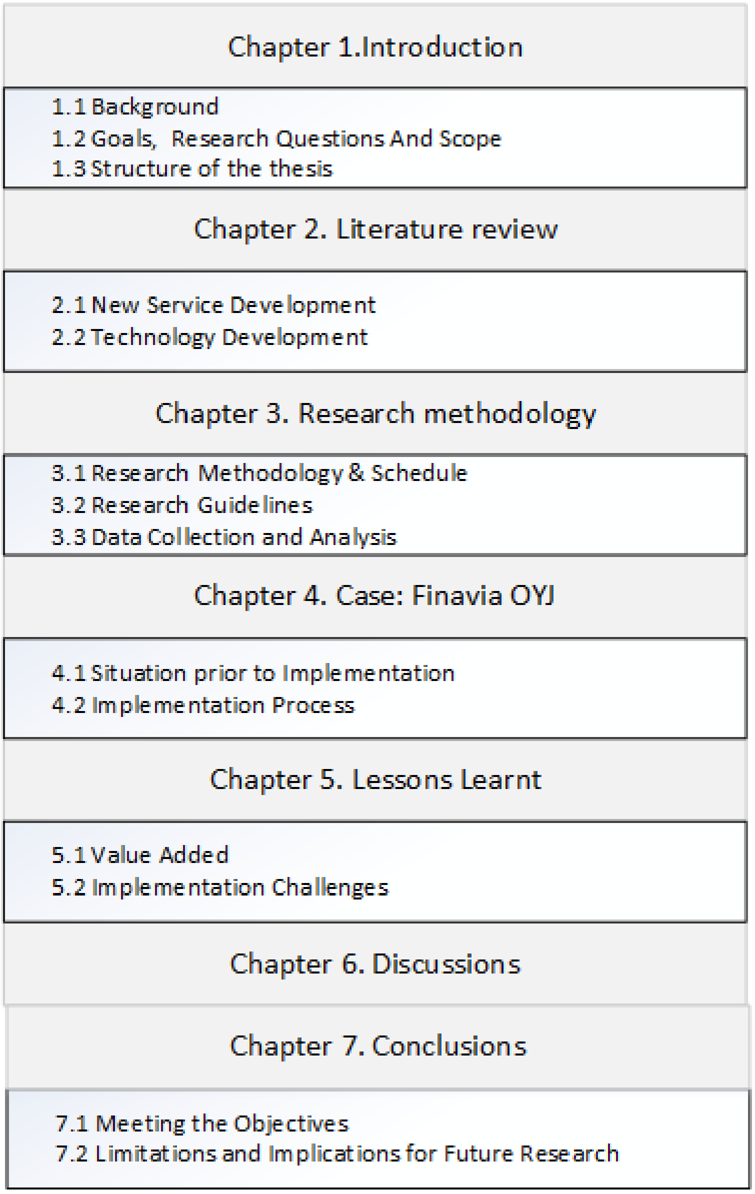

Figure 1. *Structure of the Thesis*

The literature review focuses on new service development and technology development which are keys for this study. Each section is divided into subheadings in an effort to elaborate on the elements of new service development for service providers, process changes due to the developments of a new services, and latest developments on the technology on both hardware and software level. The third chapter explains how empirical data is gathered and analyzed throughout the study. The fourth chapter presents the findings of the study with a case where the empirical data is analyzed in the light of situation prior to the implementation. The results of the study are analyzed in the lessons learnt chapter while connecting them to existing literature. The ending chapter of the thesis, Chapter 7, poses the conclusions.

2. LITERATURE REVIEW

There are two main topics that has been emphasized for the development of this research: New service development (NSD) and the technology that would be the key component for the proposed service. Both concepts are studied in detail, especially in relation the research question as presented in the following sections. The definition of new service development, NSD process model and studies made on current services at the airport form the starting point of the literature review. The technology section, explains the development of the technologies and previous cases that serve as fulcrum for the latter part of this research.

2.1 New Service Development

Development and launch of the new services have become a must considering the constant advancement in technology, changing economies, demanding customers, increasing competition, and other events in the globalized economy (Edgett 1994). Although back in 18th century service activities were not seen as a valuable endeavor in comparison to manufacturing, that mindset has completely changed in our current economy. In addition, according to Oliva & Kallenberg (2003), usually unique nature of the services makes them harder to imitate in comparison to products. They elaborate that services also lead to better margins and stable revenues which makes them a source of competitive advantage. Gao & Chen (2010) seconds this opinion stating that academic research has revealed that the service sector is now dominant in every developed economy.

Although it is known that service business amounts to a significant part of today's economy, the area is still void in academic field. Alam & Perry (2002) state that there has been little research conducted on new service development and innovation. Njissen et al. (2006) add that research efforts have been focusing on new products and systems rather than services. Gao & Chen (2010) say that existing literature focuses mainly on creating a set of the activities and concepts associated with the NSD process. However, not many research recognize the complexity of NSD due to unique nature of service characteristics such as intangibility, simultaneity of delivery and consumption, and co-production that distinguish services from manufactured goods. (Gao & Chen 2010). Jin et al. (2009) point out that NSD success rate is infamously low due to failure in identifying the key success factors and lack of the research efforts that aim to address this problem. They argue that although researchers have invested immense efforts in identifying key success factors for NSD, these studies remained descriptive and failed to provide deep insights regarding managerial concerns about NSD projects.

Jin et al. (2009) elaborate that, the change in customer's perspective on services have also made some of the research insufficient. Today's customers are demanding quality, style, and uniqueness over homogeneous products. Customization strategies aimed at providing customers with individually tailored products and services are growing in popularity. Therefore, it's necessary to deploy NSD based on service customization approach (Gao & Chen 2010). In the following section, research on the NSD process model for service providers is examined. The shortcomings of the available process models are explained under the light of previous research.

2.1.1 NSD Process Model for Service Providers

Previous studies show that understanding the processes of new service development and innovation is a key success factor to deliver successful and innovative new services (Menor et al. 2002). Additionally, the lack of a specific scientific model for NSD has been an important point of interest in new service development research (Njissen et al. 2006).

The NSD model first emerged in the latter half of the 1980s. Scholars held different views on NSD model as time passed and environment changed. Booz and Allen came up with a seven-step NSD model in 1982, which later was adjusted into an eight-step one by Bowers in 1989. Scheuing and Johnson in 1989 changed the model into a 15 step model by adjusting Bowers work. The latest model is fine-tuned by emphasizing the concept of project management and analysis of the environment analysis where the service to be brought in the early stage of conducting NSD. In 1999, Johnson improved another NSD model and integrated the cross-functional team. He also divided the process into four parts: Design, analysis, development, and market appearance as the regular cycle. (Lo et al. 2014)

The NSD models explained thus far has received criticism by scholars for their shortcomings. One of the most articulated criticism by the scholar was lack of customer involvement in the process. Some scholars assert that the risk of failure can be significantly reduced by bringing customers into the NSD model Beyer & Holtzbatt (1998). Jin et al. (2009) argue that customers are great resources of new services and ideas. They elaborate that the involvement of customer to NSD model can lead the new ideas that have great user value with better and differentiated features. Gao & Chen (2010) also emphasize on the increasing importance of customer participation in the firm's value creation as it has recently been recognized by firms and scholars. They argue that customer participation can increase the productivity of a company and enhance the service quality which will reflect an influence in customer satisfaction. Barabba (1995) adds that there is a clear need to create an NSD model that encourage customer-provider interactions during NSD in order to develop successful new services. In addition to lack of customer input, Jin et al. (2009) point out three other factors that lead to low success rate in new service development.

- Lack of NSD Strategy Management
- Lack of Process Management
- Lack of NSD Knowledge Management

Firstly, as seen in the above NSD model, New Service Development generally begins with the formation of the strategy. Jin et al. (2009) argue that a clearly stated and well communicated strategy is the key for successful development. An NSD strategy that defines the roles of NSD within the overall strategy drives and manages the NSD efforts. Besides it guarantees that NSD strategy is aligned with the company's business strategy which help management to fit the NSD efforts such as new service decisions, operational capabilities, delivery process and procedures in the big picture. According to Jin et al. (2009) best performing companies spend twice as much on predevelopment work in comparison to the worst performing ones which leads to the conclusion that the higher NSD management strategy, the higher NSD success rate.

Secondly, Jin et al. (2009) criticize the ad hoc way of conducting NSD project which seem to be common nowadays. Tatikona & Rosenthal (2000) argue that formal development processes can be used to create project reviews which not only would provide opportunities for management to intervene the project but also would assure they do not overdo it, and help in the allocation of necessary resources as well. Tatikonda & Rosenthal (2000). Finally, knowledge management is an important factor that needs to be emphasized in order to achieve successful NSD. Jin et al. (2009) assert that, rapidly changing and dynamic market where the only certainty is uncertainty, makes knowledge is of utmost importance to service companies. Know-how and skills are among the most valuable organizational values. During the development of new services having the most relevant knowledge and skill set in the development team can lead to a competitive advantage over the competitors in terms of superior customer value, cost speed and quality. Lievens and Moenaert (2000) empirically confirm that, the knowledge management activities such as communication, and exchange of information between NSD team and management is a crucial factor for NSD success.

Under the light of the previous researches Jin et al. (2009) concludes that customer involvement, strategy management, process management and knowledge management are the four key factors that lead to success in the NSD projects. Taking the aforementioned criticism into account Alam & Perry (2002) came up with an NSD model that incorporates the customer-provider interactions mechanism. The ten step NSD model and the activities that need to be performed by the customer are explained below (Alam & Perry, 2002):

1. Strategy Planning
    a. Customer Input: Feedback on financial data
2. Idea Generation

   a. Customer Input: State needs, problems and their solution, criticize existing service; identify gaps in the market; provide a wish list, state new service adoption criteria
3. Idea Screening
   a. Customer Input: Suggest rough sales guide and market size; suggest desired features benefits and attributes; show reactions to the concepts; liking, preference and purchase intent of all the concepts, help producer with go/kill decision
4. Business Analysis
   a. Customer Input: Give limited feedback on financial data, and profitability of the concept
5. Formation of Cross-Functional Team
   a. Customer Input: Join top management in selecting team members
6. Service Design and Process System Design
   a. Customer Input: Review and jointly develop blueprints, identify the failing point, observe the service delivery
7. Personal Training
   a. Customer Input: Observe & Participate in mock delivery services
8. Service Testing and Pilot Run
   a. Customer Input: Participate in service delivery process, suggest final improvements
9. Test Marketing
   a. Customer Input: Comments on marketing plan an choosing marketing mixes
10. Commercialization
   a. Customer Input: Adopt the service as trial, give feedback about overall performance of the service along with the desired improvements, provide word of mouth communication to any potential customer

Alam & Perry (2002) have proven that with the customer involvement it is possible to spark companies to provide superior and unique services to their customers in order to gain significant competitive advantages through shortened development period. Alam & Perry (2002) conclude that managers should put more effort in developing services that match customers’ needs. Fitting those customer needs with companies overall strategy, following structured NSD processes and sourcing the necessary know – how, skill set is also crucial. This section aimed to provide understanding on the need for service development, its model and shortcomings. Next section studies the identification services at the airport environment, and their inadequacies which created the need for the new service development in the first place.

2.1.2 Identification Services at Airport Environment

Appelt et. al. (2007) argue that the overall airport experience of a passenger can be demanding and time-consuming. Delays, never ending and queues occur in parking, checking-in, security screening, and boarding. Passengers are asked to prove their identity with a valid travel document at each step listed below:

- Check-in
- Security Pass
- Boarding

Joustra & Van Dijk (2001) state that the ongoing growth in aviation which led the aforementioned troubles to the passenger, seems unlimited. Many international airports show high growth figures in the number of passengers and this increase accelerated in the last decade. Most of the airlines and airports took advantage of the acceleration in the growth and enhanced their service offering. In the major hubs of airlines where service offering includes lounges, passenger are also asked an ID card, boarding pass, or frequent traveler card to prove their eligibility for the service.

Many airlines and airport operators have seen the problem, and intensified the efforts to provide additional service that would solve the problem since the early 2000s. For example, online check-in, which has become an industry standard service nowadays, was first offered by Northwest Airlines. Before the introduction of smart phones, the service was first put to use via a web site enabling domestic passengers to check themselves in and print out a boarding pass through the internet. Simultaneously, self-check in kiosks were made available for travelers who do not have access to internet (Joustra & Van Dijk, 2001).

The identification method and the overall passenger experience have remained similar even after a decade due to lack of the technology that would provide a smoother experience and fulfill the airports obligation which includes proper identification, limited luggage weight, and safety procedures at the security checkpoint (Appelt et. al 2007). Identification and access control methods have remained similar on the employee side as well. Lazarick (2001) explains that access has traditionally been granted with electronic systems using ID cards and electrically controlled doors or security points at the airport. He argues that these systems comes with risks, particularly the problems of lost badges and unauthorized access by way of piggybacking or tailgating. In the light of previous research, the shortcomings of current identification services can be listed as below:

- Aging
- Lacks customization
- Lacks flexibility
- Vulnerable to security breaches

There have been attempts to integrate technology with the current systems. The QR code readers at the boarding, self-bag drop counters equipped with QR readers among those endeavors. However these attempts had really small impact when it comes to overall passenger experience. Hans (2014) pointed out the losses that airline industry experienced due to misidentification of a luggage which damages the passenger experience even more. He suggested using biometrics during bag drop at the departure airport and pick-up at the arrival airport. He elaborated that bundling finger print information of the owner to the luggage will dramatically reduce the amount of bag that are stolen (Hans, 2014). Mccoy et al (2014) investigated using RFID technologies within employee ID badges and boarding passes as an automatic tracking & identification system to increase security and efficiency at the airports.

Later on, face recognition started to be used to identify passengers as a security reinforcement method. Spreeuwers et al. (2012) argue that automatic border control at airports using facial recognition for passport control becoming more and more common. However they have pointed out the doubts on the reliability of the eGates and conducted a study on Schiphol Airport where eGates were being tested. Following their study Opitz & Kriechbaum-Zabini (2015) study the eGate system used at Vienna International Airport. After evaluating a year of preprocessed data, the face recognition systems went offline, as the two of the three system achieved error rate below the maximum accepted level (Opitz & Kriechbaum-Zabini 2015).

Aforementioned articles focused on bringing technology as an identification method to the different parts of the airport experience. The problem here is that the purpose of integrating new technologies has been either increasing security or operational efficiency for the airport operators. However, airports today fail to offer identification services that makes the experience smoother for the passenger through the use of technology. Another shortcoming is that airport operators focus on streamlining single processes rather than bundling services together. Next chapter discusses the technologies that could be brought together to address the shortcomings of the current airport technologies described by scholars in this section.

2.2 Technology Development

In this chapter, the technologies that are utilized in this study are examined in the light of previous studies and cases. The first section of this chapter justifies the use of cutting edge wearable technology that holds an important place in the context of this research by explaining the transition from handheld technologies to the wearable ones. It also explains the development of Google's smart glass, the Glass, which is the designated hardware for this project. Face recognition is the key software element that is used in this study. The development of face recognition technology is discussed starting from its early form, the eye tracking technology.

2.2.1 Transition to Wearable Technologies

Wearable technology (i.e. body-worn electronic devices) are getting closer to become a commodity, thanks to their advantages over the examples of mainstream technologies. Sandor & Thomas (2009), give credit to wearable technologies' walk-up and ready to use aspect while Billinghurst & Starner (1999) describe three elements of wearable technology that continue attracting the users:

- Wearable technology is mobile
- Wearable technology capable of augmenting the reality
- Wearable technology is context sensitive

First and foremost, wearable technology is mobile and by definition it must go wherever the wearer goes. (Billinghurst & Starner, 1999). It is expected to lessen the inconvenience to the user as it requires less active interaction with user in comparison to handheld technologies such as smartphones.

Secondly, Billinghurst & Starner (1999) argues that wearable technology must augment the reality. Augmenting reality would mean to overlay an audio, pre-registered text or image on real world using the wearable device. On more recent articles, this opinion of Billinghurst & Starner (1999) is seconded by other scholars. For example; Behringer et al. (2000), suggest that wearability of the device and feasibility of augmented reality applications goes hand in hand. Finally, context sensitivity is pointed out as an important element that differentiates wearables from its alternatives. Context sensitivity refers to user's awareness of their surroundings. When a wearable is worn it should stream information regarding the surrounding and bring it to its wearer's attention.

In mid to late 1990's, wearable technologies were thought to become a hit within a decade. Billinghurst & Starner (1999) describe wearable technology as the new way to manage information. Their opinion on the future of the wearable technology is surprisingly accurate considering the state of the technology back in 1999. The following quote is taken from their publication about wearable devices for IEEE Magazine:

> *"…The new generation of wearables may look very much like eyeglasses or even an ordinary jacket. But with this new convenience comes a host of challenges in redefining the bond between computer and user."*

Billinghurst & Starner (1999) argued that wearable computers can come in any form. It could be small, wrist-mounted systems or bulky backpack computers as long as it comes with the three aforementioned elements. They explain that the combination of several forms of wearables as well as their combination with hand-held technologies has dramatically improved user performance in early applications such as aircraft maintenance, navigational assistance, and vehicle inspection (Billinghurst & Starner, 1999).

Bryson & McCann (2009) confirms that Billighurst & Starner (1999) were not the only ones who were enthusiastic about wearables' prospect in the short run in the 90s. This opinion was shared among many scholars. However they argue that many of the aforementioned concepts and ideas that are initially thought to form the wearable technology found their way into the mobile phones. Mobile phones, later superseded by smart phones, minimized the need for alternative technologies as they offered overwhelming amounts of functionality in one single device. The early attempts to make the technology wearable were part of military research programs like many other technologies that followed the same path to common public's use such as Teflon, Gore-Tex, and World Wide Web and so on. (Bryson & McCann, 2009). After the research phase, wearable technologies had still a long way to go to achieve the scholars' vision.

After more than a decade, in 2010s, new generation of wearables such as smart glasses and smart watches have emerged in the market as Billighurst & Starner predicted in 1999. Nowadays, wearable technology has taken a leap. With new applications being launched every day, it is getting closer to become a commodity. According to Kalinauckas (2015), the wearable technology market has exploded. There are plenty of wearable devices available in the commercial market such as activity trackers, e-health monitors, and smart watches. He elaborates that on the contrary to what happened in the late 1990's, all kinds of functions are finding their way into the body worn devices (Kalinauckas 2015).

Islam & Want (2014) suggest that the smartphone experience is bound to change in the next decade due to the predicted growth in six areas – Internet of Things, personal computing, low power performance, multimedia delivery, context awareness and finally wearable technology. While the first five target the functionalities of one could expect from a smartphone, wearable technology possesses a chance to replace the current form of smartphone experience.

Islam & Want (2014) say that in near future, flexible electronics will enable hand-held technologies to be foldable and conform to our bodies. They add that in the future, smartphones are likely to take a new form with the introduction of the set of technologies that are more readily associated with wearable technology. The smartphone is likely to evolve into a watch or apart of eyeglasses such as Google Glass (Islam & Want, 2014). Figure 2 below, illustrates the evolution of wearable technology in relation to hand-held technologies. It also shows where the previous research works and vision of the aforementioned scholars fall onto the timeline.

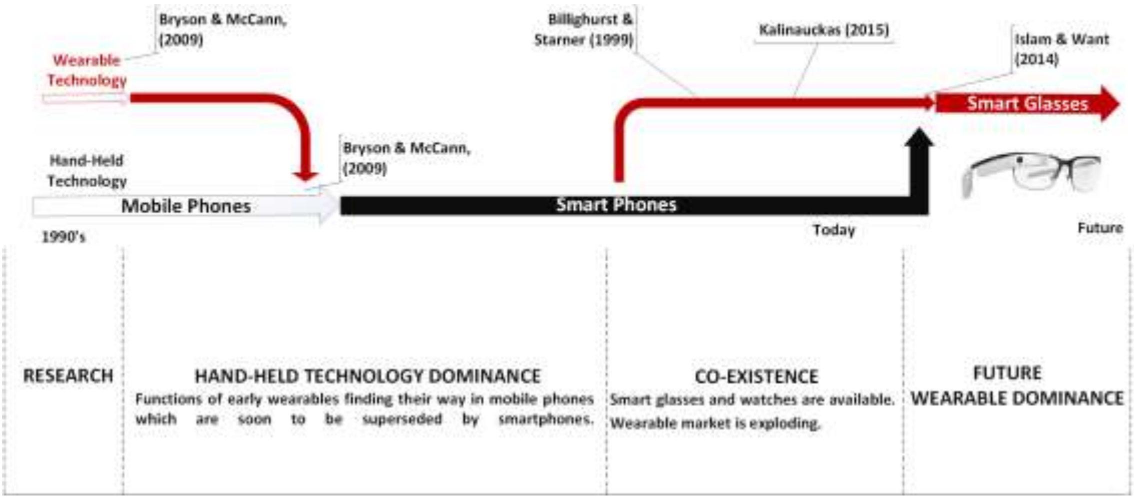

Figure 2. *Wearable technology's evolution.*

As illustrated in the figure above, nowadays we are in the co-existence phase where wearable technologies and smartphones support each other to enhance the user experience. However, smart glasses strike as the finest example of wearable technology and they are a close candidate to replace the smart phone experience in the future as pointed out by Islam & Want (2014). Nowadays there are many brands offering smart glasses to the common public. Google launched the project phase of its smart glass project, the Glass, in 2012. Although the project phase of the Glass has been finalized in 2015, it provided strong evidences for its prospect. The section below examines the literature for Google Glass in depth in order to provide better understanding on its past, future and functionalities.

2.2.2 Google Glass as Wearable Technology

Starner (2013) explains that Google's motivation with the Glass was to reduce the time between the intention and the action, which he believes to be a valid motivation for all Google's product. He elaborates that, in Project Glass' case this motivation was fueled by the lack of immediacy of the smartphones. According to Starner (2013) Google Glass is the hardware that underlines the difference between using a human – computer/smartphone interfaces and using interfaces that are extensions of the self.

With the aforementioned motivation in mind, Google announced the Project Glass on 4th of April, 2012. Naturally, the development process of the Glass dated back to late 2000's. Until 2013 the Glass was only being used inside Google facilities. This situation changed when Google delivered the Glasses for the participants of the Explorer program on 16th April, 2013. At this point, the Glass started to receive big exposure, as it was used from skydiving to sports, fashion shows to concerts. The Glass became available to anyone who wanted join the Explorer Program on May 15th 2014, for around $1,500. On January 15th, 2015 Google announced that Glass Explorer was shut down and the product was graduated from its experimental lab. Since then, Google has been working on the next version of the Glass (GlassAlmanac, 2016). Figure 3 below illustrates the Google Glass development.

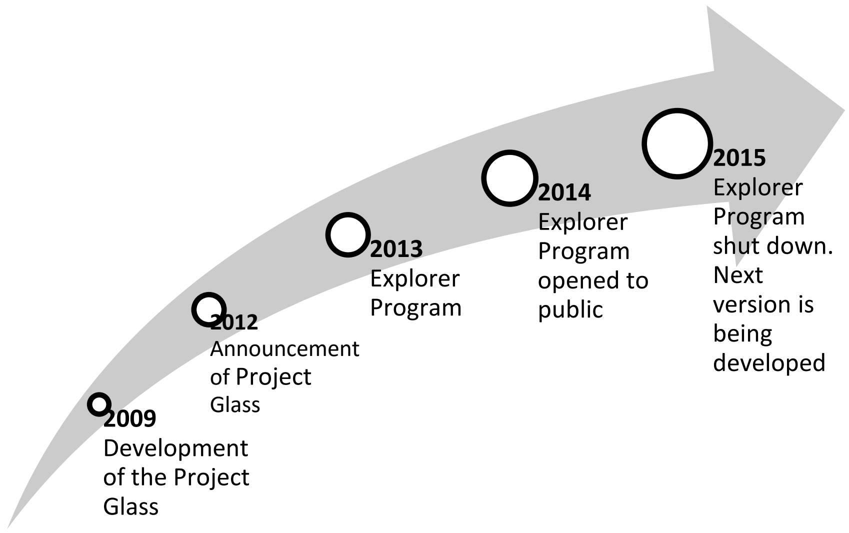

Figure 3. *Google Glass development.*

As explained in the figure above, the Glass project is suspended but not dead. The new generation of the Glass is being developed to fulfill the needs of both commercial and consumer market. The next generation of Google Glass will fold up when it's not being worn, much like traditional eyeglasses (Fortune, 2015). Despite the rumors on the new version of the Glass, the old version Glass still appeals the enterprises and consumers and even one year after the suspension of the Glass project it is still being procured from private markets.

Furlan (2013) shares the opinion of Starner (2013) on what makes the Glass appealing. He argues that Google Glass augments the self rather than the reality. He praises the Glass' head up display for being immersive despite it is small size. Glass activates the standby mode with the screen off when it is not being used. The transparent display makes you easily forget when you are not wearing it. When your attention is needed the Glass uses and integrated bone conduction speaker to notify you. If you want to continue using the Glass actively all you need to do is to tilt your head 30 degrees upward to get the Glass up and running. This is a smooth process and after using the Glass for some time, it feels natural. In addition to gesture command function, you can use the touch pad and voice command to control the device. The features that are offered in the explorer edition of the Glass already cover a significant portion of what you would expect from a smartphone. You can send and receive emails or receive, search using Google, get directions, and make calls (including video calls). Its point of view camera a makes taking a picture or recording a video easier than ever. Many scholars including Furlan (2013) have been amazed by how simple yet competent the hardware is. Figure 4 below shows the teardown of the Glass.

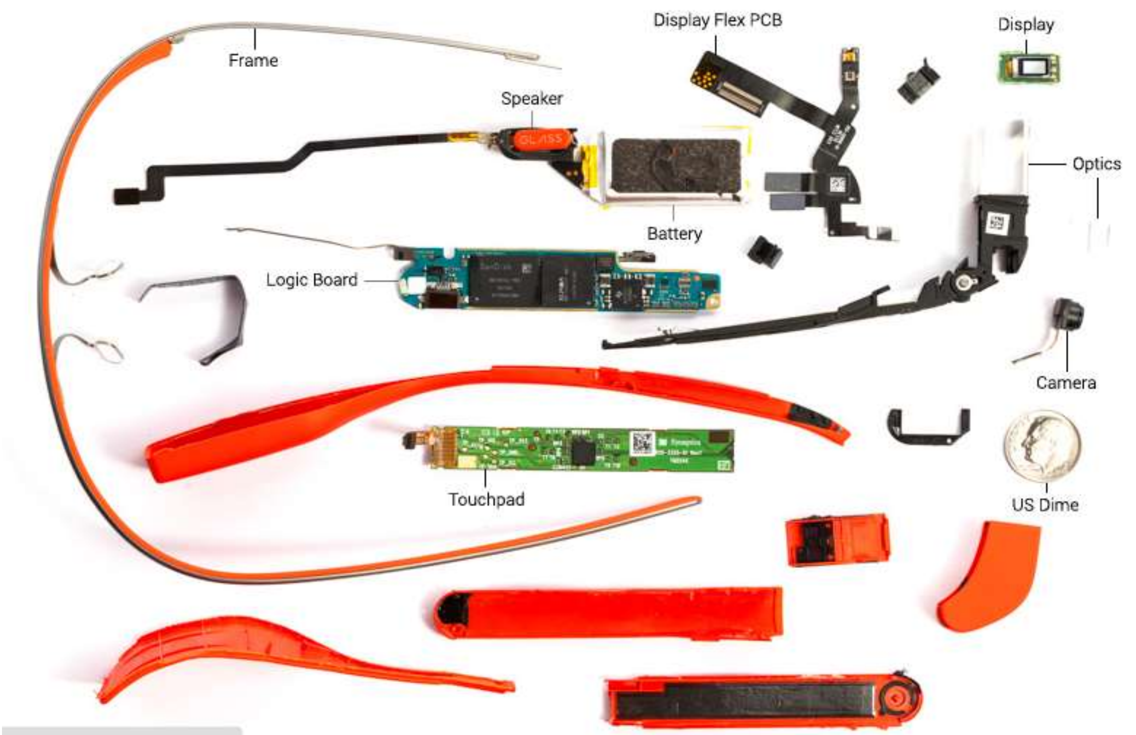

Figure 4. *Google Glass teardown (Photo courtesy: Scott Torborg & Star Simpson)*

In addition to hardware and software capabilities, performance of the smart glass under different tasks plays a role in user preference. Elder & Vakalouidis (2015) points outs the fact that smart glasses have lately been under the spotlight for a variety of technical and usability reasons. They add that the area is active with other big companies involved in the development of smart glass devices. Therefore it is important to specify the area of use the Google Glass for maximum usability.

Elder & Vakalouidis (2015) explains that the initial aim with Google Glass was to market it as a developer tool, despite the promotional videos hinted otherwise, with many other areas of use. It was expected that developers would drive the market with the applications they create. It soon became clear that the device had great potential as a versatile platform. During the life span the Glass Google tried to persuade the world that Glass was something that you would need in your daily wardrobe. As soon as the Glass made available to explorers Glass wearers seen doing everything from checking email, and visiting coffee shops to attending concerts and participating in extreme sports. In short, Google wanted people to develop their own use of Glass – whatever that might be. Therefore Elder; & Vakalouidis (2015) categorizes the Glass as a consumer product with wide customization options and sleek outlook. They have also added that the Glass could also be a good choice in Culture & Tourism, and Medical industry.

However, many scholar thinks that the Glass comes with several issues that need to be addressed in the future. Kalinauckas (2015) mentions the following issues:

- Price
- Battery life

- Privacy issues
- Lack of applications

Firstly, Kalinauckas (2015) argues that $1500 price tag make the Glass an unrealistic options for both consumers and enterprise workforces. Secondly, Google's estimated that battery would last a day long where in reality it is not anywhere close to that estimation if you use the camera for a picture or a video recording. Thirdly, due to built-in camera an audio system many people considered explorers wearing the Glass as a threat to their privacy. The Glass was banned from several establishments a result. Lastly Kalinauckas (2015) explains that lack of useful applications for the Glass makes the less attractive for the user as people would be reluctant pay $1500 for a device that cannot do what their smartphone is already capable of doing for the half price.

As discussed in the previous chapter, there are several methods and hardware available for ID management in airport context. Integrating the Glass to this process would require Glass to fulfil certain tasks. Below table summarizes the Glass' features that are explained by the researches elaborated above.

Table 1. *Google Glass' features from previous articles.*

Hardware	**Area of Use**	**Features**	**Issues**
Google Glass	Consumer	Easy to operate, hands free use	Price
	Tourism	POV Camera	Battery
	Culture	Touch Voice Gesture Command	Privacy Issues
	Medical	Internet Connection	Lack of Applications
		Sleek outlook	Commercial Availability

As seen in the table above the Glass comes with many useful features. On the other hand, its limitations could decrease the area of use depending on the task. Following section, examines the roots of face recognition as a biometric verification method. It also explains the working principles of the face recognition which will justify the hardware capabilities of the Glass that are highlighted with in the above table. Next section explains the literature for the face recognition which will complement the Google Glass in this study.

2.2.3 Face Recognition

Biometrics is now known as an essential technology wherever secure access control is a necessity. Physiological characteristics of humans are used to identify individuals. Face of an individual is naturally one of the attributes usable for biometrics verification. Face-recognition is a computer technology which uses facial features of people for identification purposes. Recently, it has become a hot research topic as it provides the researcher with many different characteristics, such as direct, friendly and convenient. As face is one of the most distinguishable characteristic of the human body, improvement of the face recognition systems as identification method will introduce brand-new management ways for state security, social security, financial security, social welfare and e-payments (Liu, 2014).

Horiuchi & Hada (2013) explains that the research emerged mostly in western countries on 90's. Compared to the studies at that time, accuracy rate of face recognition has been improved significantly today. Zafaruddin & Fadewar (2014) elaborate that early Face Recognition Systems used simple geometric models whereas now face recognition has become a science itself. Ekenel et al. (2007) justifies the aforementioned emphasis on face recognition studies with the need for person identification in our daily lives. They argue that person identification is the key for smart interactions. Either in form of an assistant in human-human interactions, or in human-machine interactions, the ability to automatically identify a person provides the most important element of natural interactions; personalization. According to Ekenel et al. (2007) this ability can be also be used to improve the performance of other perceptual technologies. Performance of race, mood, expression analysis systems or appearance-based head pose estimation systems can be improved by implementing person specific models. Among the person identification methods, face recognition is recognized as one of the most natural ones, as we also use the characteristics of a face to identify the person we are interacting (Ekenel et al., 2007).

Face recognition technology is now widely used in various applications Horiuchi & Hada (2013). It has demonstrated far reaching benefits to corporations, the government and the greater society Zafaruddin & Fadewar (2014). However; it took more than a decade for it to become a reliable technology as it is now. Figure 5 below illustrates the road map of the technology from early 90s to today.

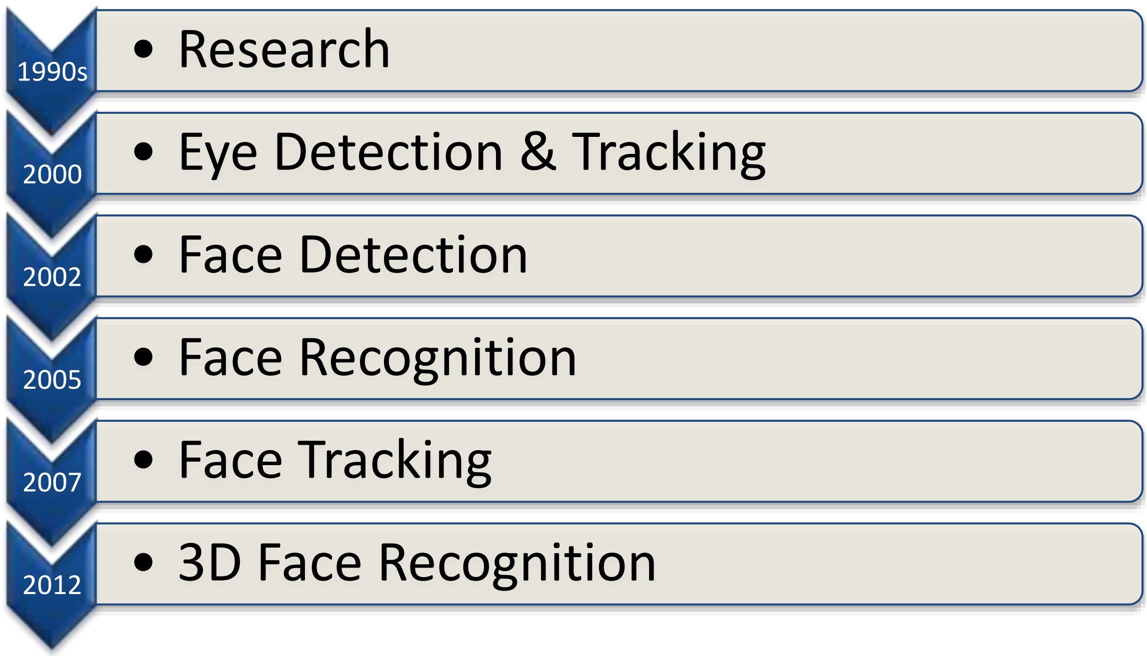

Figure 5. *Evolution of face recognition technology (Adapted from the Ayonix.com)*

Face recognition has come a long way as illustrated in the figure above. Before the emergence of three dimensional face recognition the use of technology two dimensional image based methods were being used. Jelsovka et al. (2012) argue that 2D face recognition methods were inherently limited as it was vulnerable to the changes in the imaging factors such as illumination and pose. 3D face recognition has the potential to improve performance under the uncontrolled conditions as the shape of faces is independent on the illumination and pose where as an image of the face might be affected adversely from the variability in these factors. The insensitivity of 3D face recognition models to the imaging factors make accurate face recognition in difficult application scenarios possible. (Jelsovka et al., 2012). 3D face recognition system utilizes depth map images to extract 2D local features. The block diagram in Figure 6 below shows the processing steps to generate a depth image from 3D range data.

Figure 6. *3D Face Recognition Model (Adapted from the Ayonix.com)*

Once the image is grabbed from the source the first step is to detect the coordinates of the face. In other words, the aim is to locate the face within the the given image. Based on the initial points, the ones that are easy to locate or generic, of the face, all relevant points are generated and the 3D mesh fitted to the face. At the fourth step several corrections done such as 3D illumination and pose correction, shadow minimization. The following step is where the extraction of the face feature is completed. Generic features such as gender, age and personspecific features are extracted and stored in the database. The image is now ready for the face matching. Whenever the person whose image wen through the aforementioned steps captured by a camera that is equipped with the face recognition alghrotim face matching occurs. The system gives scores from 0.0 to 1.0 to describe the accuracy of the face match (Ayonix, 2016).

Research efforts intensified on face recognition as it is the most promising form of among biometric verification methods. It is important to investigate the previous researches to understand the evolution, and the working principle, which was the primary aim of this section. Following section focuses on the previous use cases where face recognition technology is being used combined with the wearable technologies.

2.2.4 Previous Cases: Google Glass and Face Recognition

Gyrödi et al. (2015) argue that using wearable devices have recently become a common trend. Having a dynamic and efficient interaction with the surrounding environment is the goal that wearable devices want to achieve. Object, gesture, face detection through the use of wearable devices are the primary steps to achieve this goal are big challenges and critical features to prepare them for every-day uses. Taragi & Babaci (2015) emphasize the need for object & face detection through a wearable device by underlining that, it is a natural habit to forget common things, names and faces which are of less importance for your daily activity.

Google Glass has been the chosen hardware for object detection and recognition in several studies. It has been proven that a head mounted display reinforced with object/face detection ability, can indeed improve the performance in the context that the system was being developed for. Taragi & Babaci (2015) studied the object detection through Google Glass which has been predominantly done via using wearable or stabile sensors. They argue that recognizing objects, and/or identifying them in an image or video is one of the ultimate task of computer vision. This is something humans are able to do with little effort, despite the fact that the image of the objects may vary significantly depending of the viewpoints, size, scale, and if it is preprocessed or rotated. In their study, a Google Glass equipped with the object detection software was put to a test in different illuminations provided by indoor/outdoor environment. This method was able to successfully recognize a pre-defined object in real-time and detection was shown to user with rectangle surrounding the object. They concluded that server and client side of the process can be separated to increase the processing speed thanks to accessibility and portability of the wearables.

Being able to detect a pre-defined object is the first step towards recognizing more complicated patterns such as human faces. Casado et al. (2015) used smart glass to detect faces and register them to database. For this purpose, they have developed an application prototype that detects faces in real-time. Differing from Taragi & Babaci (2015), Casado et al. (2015) did not divide process into server and client sides. The application developed to run independently on the smart glass. Faces are continuously being searched in the field of view by their face analysis subsystem. When smart glass detects a face, a global variable created that indicated the position of the face. To complete the recognition, local database is searched for the similar variable. If the face is not registered to the database prior to recognition, relevant facial features are saved in the database with a new identifier. Casado et al. (2015) argue that, during the testing, the proposed system was able to run in real-time on a smart glass with an acceptable accuracy. In their study, Casado et al. (2015) mainly focused on latency, energy & efficiency of the proposed system. Particularly, the revelation of the trade-off between resolution and processing time has been the main focus.

Györödi et al. (2015) argues that although it is common to forget people's faces and names it still creates inconvenience in social situations. Therefore, they developed a solution to overcome this unsettling habit by recognizing the faces you met before. The system is programmed to inform the user by telling their names and a short description that was recorded at the first encounter. They assert that this could naturally enhance the quality of your conversation with the correspondent. They elaborate that the main advantage is having only one device for the whole facial recognition process, which makes it extremely user-friendly. User is able to recognize and retrieve details of a face – that is previously stored in the database - with just a voice command and or by tapping to the side. In addition, there is not much computational work required from the Glass as the image processing is done on a dedicated server. Györödi et al. (2015) elaborated that this solution can be put to use in different areas such as; criminal investigations by police allowing them to recognize criminals.

Researchers indeed applied similar solutions in different areas. Ruminski et al. (2015) exploited the advantages of being able to bring up records by just looking to one's face in healthcare context. They have focused on the use of smart glasses and face recognition by integration of the medical data gathered from the different sources. Patient's medical record, allergies, special needs are among the information that could be useful in the examination. Ruminski et al. (2015) concluded that although traditional audio/visual examination still remains as the fundamental method of patient/health professional interaction they believe that adopting this method can lead to many other useful applications in health care as it is able to provide important information to the healthcare professional in an unobtrusive manner.

Although the scope of the previous studies might look similar, they have their differences as their focuses and implementation methods are different. Each research used a different type of recognition method, the real challenge came from the hardware limitations which was also pointed out by many other scholars as explained in the previous sections. The scholars utilized different approaches in terms of database registry, dependency of hardware computational power and so on challenging the limits of the hardware. Table 1 below summarizes the previous researches and their respective challenges, methods and conclusions.

Table 2. *Previous Cases where smart glasses used with face/object detection ability. (Images are taken from the corresponding studies)*

Scholars	Detection Type	Registration to Database	Challenges	Vision of the user (Example)
Taragi & Babaci (2015)	Object Detection	Pre-Registered	Battery Life	
Casado et al. (2015)	Face Detection	Pre-Registered +Registration on Spot	Latency	
Győrödi et al. (2015)	Face Recognition + Record Display: Acquitance Reminder	Registration on Spot	Device Memory Overload	
Ruminski et al. (2015)	Face Recognition + Record Display: Medical Record Display	Pre-Registered	Battery Life Due to High CPU usage	

As seen in the table above different researchers pursued different approaches. For example while Győrödi et al. (2015) relied on the hardware memory to save the faces, which then returned as a challenge as the hardware's memory is only twelve gigabytes (Google, 2016). Ruminski et al. (2015) attempted to overcome this challenge by using the smart glass to only display the information that is saved in the remote databases. The information is fetched & shown to user upon each successful recognition. Constant information flow with several databases, however, caused a high CPU usage, which reduced to battery life significantly. Battery life was also pointed out as a major problem in Taragi

& Babaci (2015) while Casado et al. (2015) suffered mainly from the latency, between the time face recognition request sent, and the feedback is displayed.

This section concludes the literature part of this study. In this chapter, two main concepts, new service & technology development were introduced. The literature studied in this chapter serves as fulcrum for the empirical part of this study. Next chapter provide details on research methodology and the methods used to gather data that is utilized in the empirical part.

3. RESEARCH METHODS AND MATERIAL

In this chapter, the path and nature of the thesis is explained by elaborating the reasoning behind each research choice. The first section of the chapter presents the methodology and framework used in the form of a qualitative and design study. It also illustrates the schedule followed throughout the thesis work. Literature review from scientific and non-scientific sources are included in the qualitative data gathering method to provide better understand to the phenomenon that is described in this research. Empirical data is gathered through on observation, surveys and interviews. The latter section reveals details of data collection and the analysis such as number of the employees and passengers involved in the study.

3.1 Research Methodology and Schedule

Different research methods are available in order to study or analyze different ideas or concepts. The types of method should be selected in accordance with the nature and subject of the topic (Cooper, 2003). This thesis has been conducted as qualitative, quantitative and interpretative design research project. The opinions of industry professionals, concerned employees are analyzed to create and evaluate IT instantiations (i.e. implemented and prototyped systems) intended to increase organizational efficiency and service quality (Peffers et al., 2007) in the light of predominant knowledge and comprehensive literature review.

According to Denning (1997) and Tsichritzis (1998) design research aims to create innovations that define the ideas, practices, technical capabilities and products. They argue that, analysis, design, implementation, effective and efficient use of information systems can be accomplished through this search for innovations. This view on design research is shared among many scholars. Hevner et al. (2004) emphasize that design research targets, utlity, quality and efficacy while Winter (2008) adds that science research constructs and evaluates generic means-ends relations. This practical aspect of design research is perfect for this research as the goal of this project is to create an IT instantiation that serves as a solution for problem that initiated the research. According to Hevner et al. (2004) design refers to both process and the product (i.e. design artifact) which come hand in hand. They argue that design process is set of activities that results with an innovative product (i.e. artifact). The evaluation of the artifact provides feedback and understanding regarding the problem. Therefore, the quality of design process and the product is improved through the iteration. This build-and-evaluate loop is iterated numerous times until the final design artifact is produced (Markus et al. 2002). Figure 7 below illustrates how the iterative method works through the process model of design science.

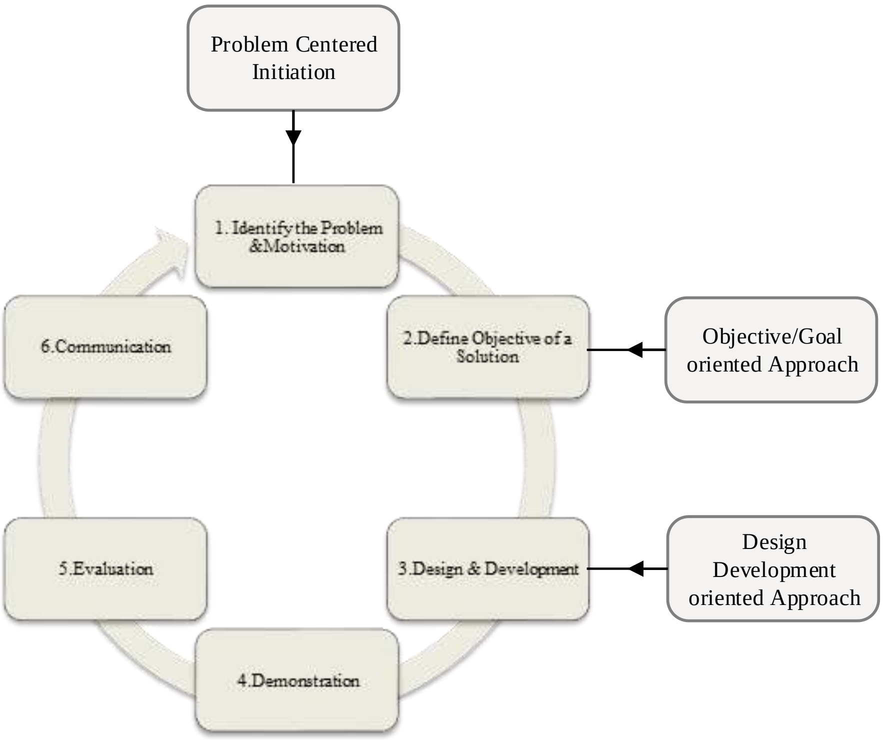

***Figure** 7. Design Science Process Model (Adapted from* (Peffers et al., 2007)

Gummesson (1993) described five qualitative research methods: use of existing data, questionnaires, interviews, observation, and action science. These methods are used to complement the design science process model illustrated above. The problem is identified through interviews with Finavia management. Questionnaires and interviews are also used in order to define the objectives for the solutions. Observations are used to determine design and development needs the interviews with Finavia management defined an important objective for the project to proceed. The proposed solution decided to be tested internally with Finavia employees, due to high risk of backlash from the passengers in case of failure. The first part of the questionnaires is conducted with employees as the research topic raises questions regarding privacy issues. This way, they were invited to opt in and their inputs towards the solution were welcomed. In this project; the capacity of the selected wearable device will be tested so the aim is to get as many employee as possible involved in the first step. Another set of questionnaires sent to the premium passengers to collect data regarding their awareness of the latest technologies, satisfaction rate with the current airport services. These numbers are used in external communication with the common public in order to demonstrate the value of the proposed solutions.

Throughout the project Finavia granted access to its departments and employees. The questionnaires are completed using online survey services. Observation method was used to determine the design and development needs of the proposed solution. As the solution was decided to be tested within the Finavia employees, employee security checkpoint two observed at Helsinki Airport Terminal 2. The input from the observations used to determine the steps, speed and design needs. After the solution was proven as a concept it was decided to bring it to the passengers' attention. Observations took place in the Premium Line Security Pass point at Terminal 2 where frequent flyer card holders go through security. The input from this observations, feedbacks, and test results were used to design the process that would fulfill the requirements of the use in passenger context. The test and launch of the solution at the premium pass was initially included in the project plan. However; due to some unforeseeable challenges, the commercialization of the product left for future studies.

This study completed in six steps, starting from early December 2015 till mid-August 2016. According to original plan literature review and the first part of empirical studies were planned to be completed late February. However; due to organizational change in Finavia OYJ, literature review and first part of empirical studies was delayed and completed in late March. A general timeline for the research is shown in the Figure 8 below.

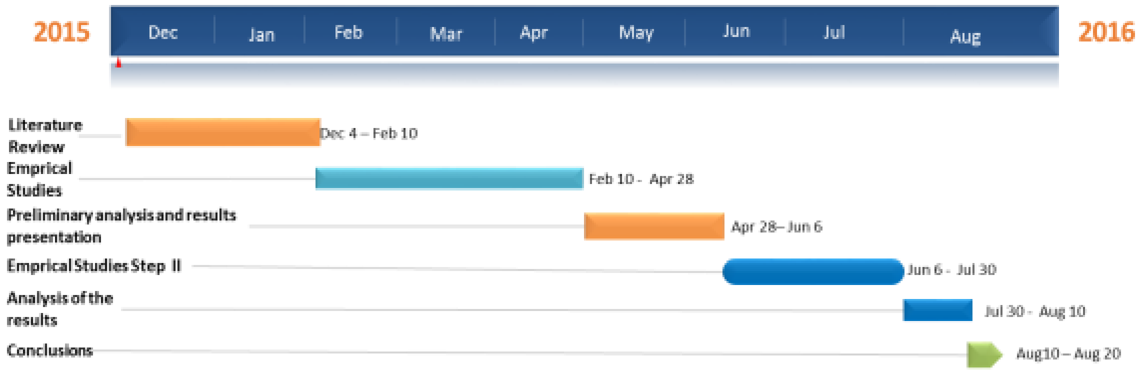

***Figure 8**. Research timeline.*

During the first two months of the project the literature review was conducted. Literature review followed by the first set of empirical research. In this phase, researcher completed sourcing for the software and hardware requirements, recruited 3rd party application developer, and employees for the test to be conducted at the security checkpoint. User stories were collected through observations that took place at the test location as well as the premium security pass point. Initial back-end and user interface also designed and delivered to the developer. This part of the empirical studies continued with the tests with the employees that was supervised by the researcher. Through, observation and interviews during the test preliminary results were gathered.

The outcome used in the second step of the empirical studies to improve the user interface design and adapt the application for the use at the premium security pass. Researcher also conducted additional observations at this phase. Further design and development requirements delivered to the developer. The results that the app deliver were analyzed considering the achieved acceptance rate versus the industry standards. The conclusions and artifacts produced by the research delivered to Finavia OYJ in August.

3.2 Research Guidelines

Hevner et al., (2004) argue that design science is fundamentally a problem solving process during which knowledge and understanding of a design problem and its solution are acquired in the building and application of an artifact. They have derived 7 guidelines from the fundamental principle explained above. Table 3 below explains those seven guidelines with the findings specific to this study which are acquired through the methods explained in previous section.

Table 3. *Research guidelines for design science. Adapted from Hevner et al. (2004)*

#	Guidelines	Description	Case Specific Example
1	Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.	An Android application that makes face recognition possible for premium passengers on wearable devices in airport environment.
2	Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.	Premium passengers were not satisfied with the services at the airport. It appeared that they did not feel privileged enough, in terms of the speed and quality services they are receiving at ID checkpoints
3	Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.	Accuracy rate of the face recognition, increased satisfaction rate of the premium passengers and speed in ID checkpoint processes.
4	Research Contribution	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.	The clear contribution of this research is the design artifact: the first smart glass application equipped with face recognition ability to conduct airport operations.
5	Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.	Prior research in developing new services, face recognition and wearable technology powered systems serve as a foundation for this work and deficiencies of these approaches for the examined problem type.
6	Design as Research Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	The solution is designed in the paper through analysis of the business process requirements at security pass points. Identification of the features provided by surveys and interviews are also utilized.
7	Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.	This thesis provides information to technical, managerial and academic audiences. While the empirical part of study provides technical and managerial details such as application design features and value proposition, the thesis also motivates academic audiences with in-depth review of literature and research methodologies.

This thesis is conducted in the order of the process illustrated in the process model of design science and following the guidelines explained table above. In this case, the researcher pointed out the problem at entry point problem centered initiation whereas case company had substantial effect in shaping the objectives and goals. Following chapter provides a profound understanding on the role and impact of data gathered through the methods emphasized on Section 3.1.

3.3 Data Collection and Analysis

Data collection commenced in two steps in the course of the study. The first set of data collection took place prior to implementation and second one was completed in the form of interviews after the test phase with employees. The method used for gathering data relevant to pre-implementation phase was questionnaire. An online questionnaire that consists of thirteen question sent to each concerned employee via e-mail. Apart from its immense effect on spreading the word throughout the airport, the questionnaire was structured to reveal crucial information in there categories as listed in the Figure 9 below.

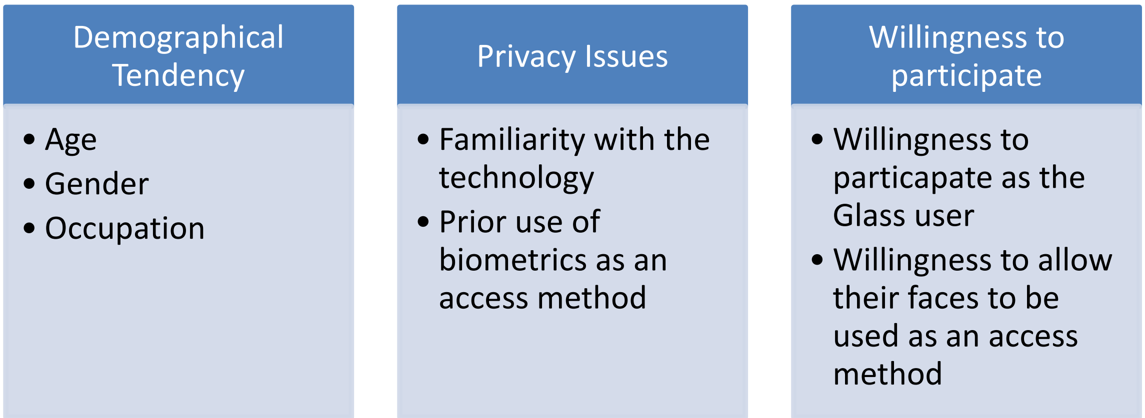

***Figure 9**. Questionnaire structure*

As briefly explained in the figure above, the ultimate purpose of the questionnaire was to gather participants who would allow their faces to be used as an access method during the test. However, the questionnaire was also aiming to understand the need, worries and expectations of the employees. Therefore, their stance & experience on privacy issues, opinions on overall idea studied under the light of demographical tendency. . For example, after realizing the low turnaround from female between 30-45 years of age, an employee falls into that category was recruited to be the face of the promotion campaign. To encourage the involvement of the employees, they were given to chance to influence the hardware decision through the questionnaire.

Despite the fact that the questionnaire indeed raised an awareness among the airport employees, the amount of responses remained low due to reasons listed below:

- Unfamiliarity with the technologies involved - among employees over 35 years
- Value proposition was ambiguous for the unknowing employees

- Employees were intimidated by the privacy concerns

The questionnaire forwarded by the Finavia OYJ Communication Department to the companies that operate in Helsinki Airport and frequently use the designated test location. Only 39 out of possible 512 responses collected in two weeks period which was significantly lower than the designated number of responses. The turnaround among the responses is illustrated in the Figure 10 below.

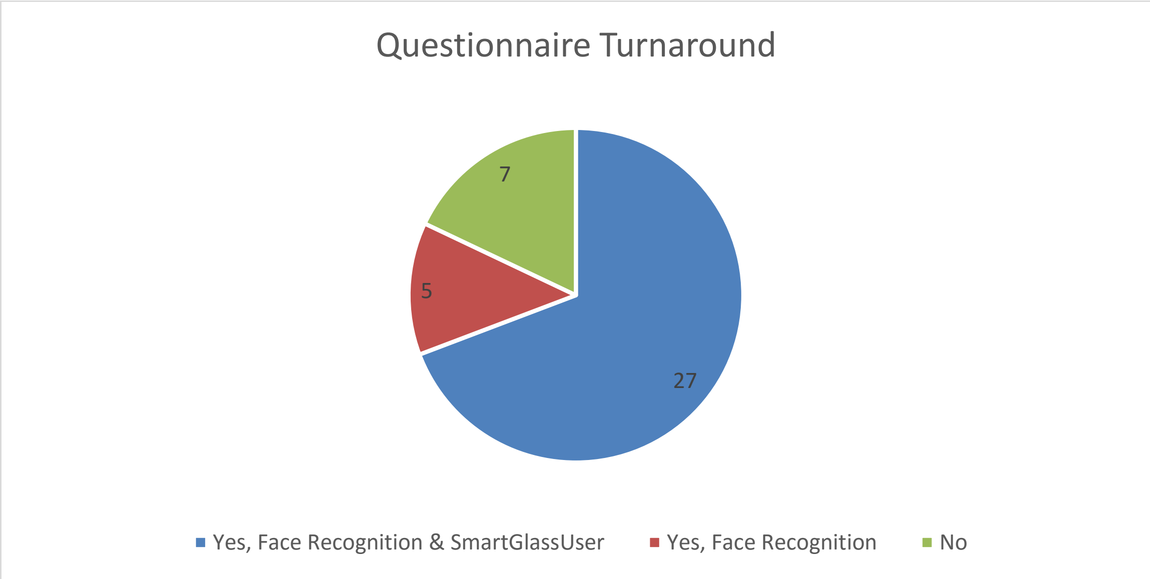

*Figure **10**. Questionnaire turnaround*

Out of 39 responses 27 of the employees agreed to use face recognition as an access method and they volunteered to use the Glass. 5 of the responders only agreed to take part in the face recognition while 7 of them refused to take part. Approximately 400 employees were using the security point of concern every day. In order conduct a realistic test which would prove the robustness and accuracy of the face recognition through smart glass the aim was convince as many employees possible. As the questionnaire provided only 32 participants along with the reasons for the low turnaround, a second participant recruitment campaign started where face to face sessions are conducted. This added another step to data collection step as illustrated in the Figure 11 below.

***Figure 11**. Data Collection Process*

In order to overcome the reasons that reduced the turnaround in the first step, a stand set up in the employee security checkpoint 2 which is a designated test location. Researcher, took time to explain the project for each a potential participant. In addition, a reward offered for each employee who agreed to take part in the tests. This approach, increased number of participants to 112 within one week. Once the designated number of test group member is reached tests were conducted. The method for data collection utilized at this step of this study consisted of semi-structured interviews with the security screeners who used google glass to identify the test group members, hereafter referred as user, and test group members. Table 4 below summarizes the interview setting.

Table 4. *Summary of the after test interviews*

Person	*Interviews*	*Duration*	*Emphasis*
User 1	1	15	User Experience
User 2	2	15	User Experience/ Overall Feedback
User 3	1	15	User Experience
User 4	2	15	User Experience/ Overall Feedback
Test Group Member 1	1	15	Overall Feedback
Test Group Member 2	1	15	Overall Feedback

The interviewees were participating actively to the tests, and interviews took place at security checkpoint 2, the location where the tests were commenced for two weeks. The users were employees of the company that was responsible security at the airport whereas test group members were from different companies who were among the 112 that opted in to take part in the project. Number of Glass users kept to six in total in order to ensure gradual improvement on user interface through iteration method. Four out of six users were interviewed. Interviews focused on two main topics. Interviews with the users focused on user experience and identifying ways improve the application robustness and reliability. Interviews with the test group members focused on receiving feedback on the new access experience, opinions on future use of the application. 9 interviews were conducted altogether. The interviewees from the test group members selected according to the frequency of the use of the service, and interest they have shown to the technology during the process.

The interviews started with the interviewee explaining their background and the knowledge that they have about the technologies being used. Then the interviewer continued with clarification of the concept during which the interviewees provided with insights to working principle of face recognition and smart glasses and their integration with the airport access modules. The interview continued with different set of questions according to interviewees' role and type of feedback required by the interviewer. The structure of the interviews is illustrated in the Figure 12 below.

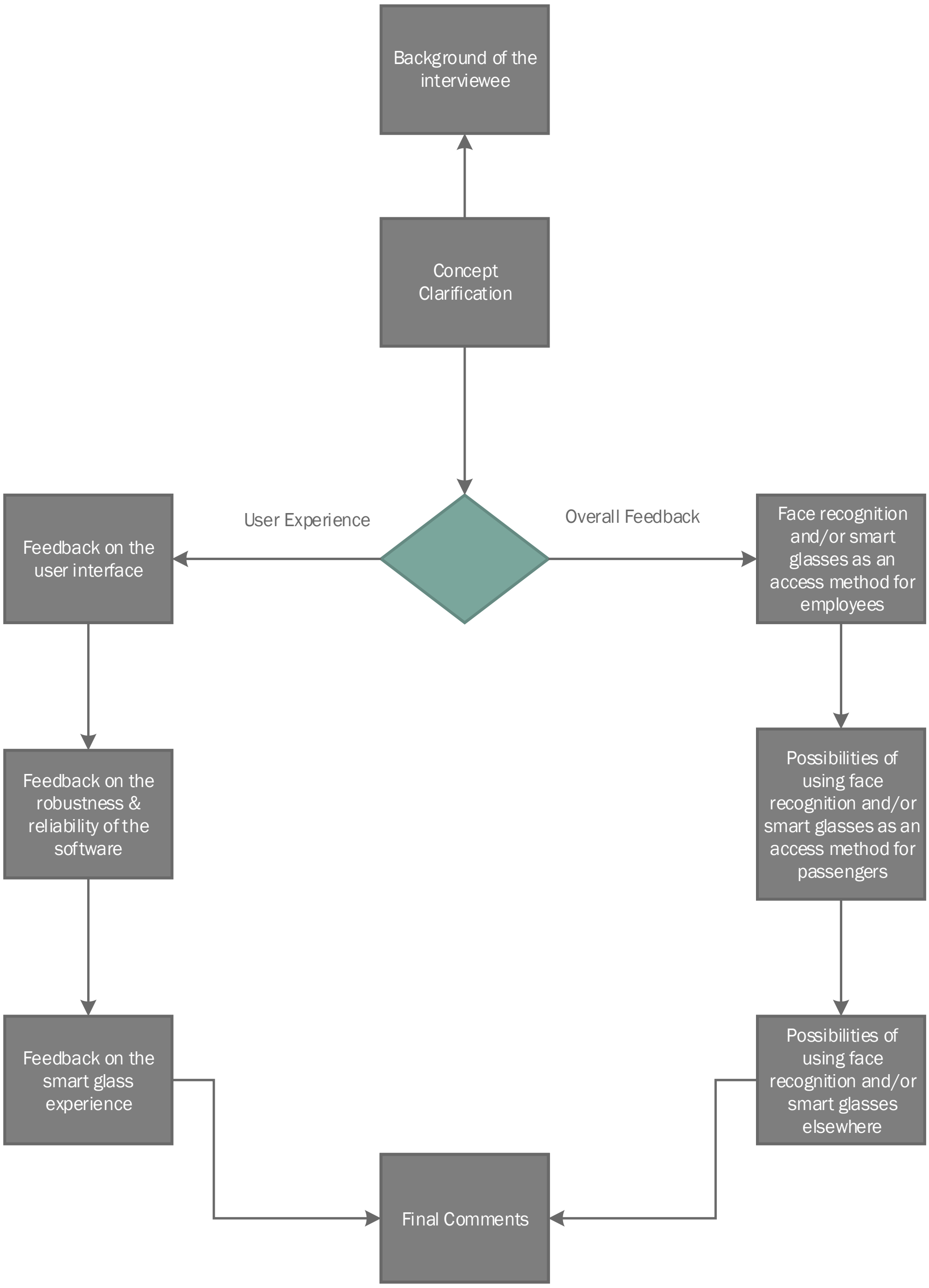

Figure 12*. Interview structure*

Following set of questions were aiming to determine the overall experience of the test group members before proceeding with questions regarding the possible adoption of the technology in different contexts at the airport. The emphasis was on improving the user experience in both hardware and software side during the interviews with users. The answers collected during this interviews used to iterate until the application fulfills the requirement of the work that is to be done and provide ease of use for the user. The improvement made on the user interface, software and the hardware side is explained in the following chapter. The data collected from the interviews with test group members analyzed and utilized when determining the roadmap after the tests which confirmed the reliability & robustness of the proposed system.

The data on the technical feasibility of the face recognition collected in a log file. In th log file each recognition request that was sent to server were saved regardless of the success or the quality of the recognition. Using this log file, technical feasibility of the face recognition examined in terms of the minimum accepted match rate (i.e. score) which was explained in the Chapter 2.2.3. The analysis of the data, combined with the feedbacks from the interviews, used together improve the overall system performance and user experience.

4. CASE: FINAVIA OYJ

Finavia OYJ is a state owned Finnish company that operates twenty two airports in Finland including Helsinki Airport. The company aims to make Helsinki Airport the transfer centre of the Northern Europe by the year 2020. According to Helsinki Airport Development Program (2014) that would mean that getting ready for twenty million passengers annually. The biggest endeavor of development program is to expand the terminal building by %45 and the construction started on January 2016.

4.1 Current Status & Problem Statement

Expanding the physical capacity of the airport will not be enough to host twenty million passengers. For example, waiting time at the security check point of terminal can increase up to 35 minutes in the busy seasons. Therefore, to be able to host twenty million passengers, operational efficiency needs to be increased, flawless security measures needs to be adopted. What is even more challenging, that all needs to be done without compromising or even increasing the service quality in order to remain as one of the top destinations in passengers' eye. Constant improvement on these areas have always been welcomed and encouraged by IATA. They revealed their vision on Future Passenger Experience to serve as a guideline to the airports (Best, 2013).

Fortunately, Finavia OYJ Management understands that physical capacity and enhanced passenger experience goes hand in hand in reaching the goals of the Helsinki Airport Development Program. When the researcher approached Finavia OYJ with the idea of using wearable technology equipped with face recognition capability in order to make improvement on the aforementioned areas and to materialize IATA's vision, fruitful discussions had taken place on where and how to pilot this technologies.

During an interview that took place in Helsinki Airport on 24th of September 2015, Eero Knuutila, Head of Service and Development at Finavia stated the following:

> *"…Our internal discussions have revealed that premium passengers and business class passengers do not feel appreciated. The technology can be presented to service of those passengers at Premium Line Security Pass, so that we can say them that Helsinki Airport recognizes and appreciates your loyalty and your traveler status."*

After this discussion, studies focused on ID management processes and services at Premium Line Security Pass. The subsection below illustrates the need for improvement in the chosen area in the light of methods and technologies that are currently being used.

Subsection that follows aims to present better understanding on expectations from a possible investment on this solution as well as possibilities for use in other areas.

4.1.1 Current Identification Method at Helsinki Airport for Premium passengers

The ID Management Services at the airports (i.e. airport's ability to recognize its passengers) are superficial. In other words, for a business class passenger or a frequent traveller card holder, the travelling experience is almost the same until they board the plane. Although there are ongoing efforts to enhance passenger experience by Finavia OYJ, Helsinki Airport suffers the same problem due to the limitations of current airport technologies. Therefore; current additional services for high-end passengers at the Helsinki Airport are man-made and lack the notion of technology. These services usually appear in the form of an additional, queue free line in check-in, boarding, and security pass.

Premium line security pass point which is a security pass point to duty free are specially dedicated for premium passengers and business class passenger was chosen as the pilot are for the project. Thus, it is important to study and understand the ID management process at that point in order build the value proposition. Figure below illustrates the process prior to implementation.

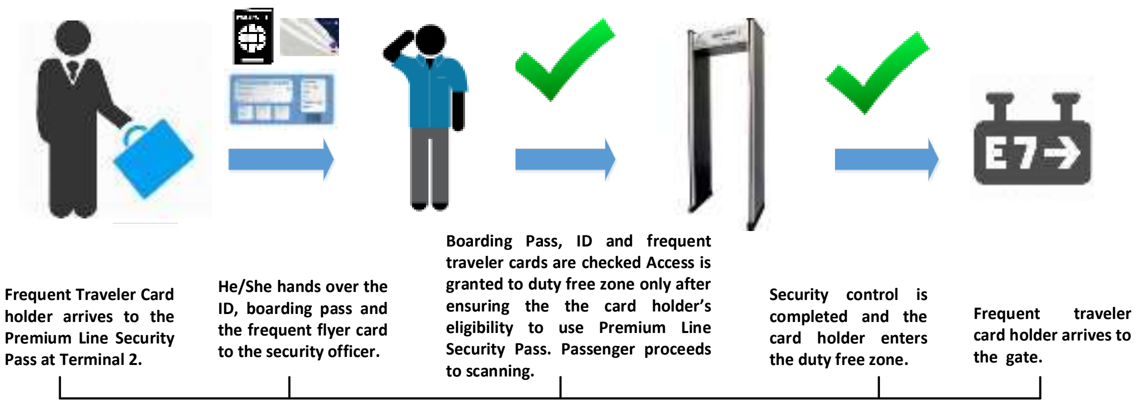

***Figure 13**. Frequent Traveler Card Holder at Premium Line Security Pass*

As seen in the figure above technology is not being utilized visual ID checks at Premium Line Security Pass. Security officer needs to ensure passenger's eligibility to use premium pass rather than the regular one. To do that, passenger is asked to present his ID, boarding pass and the frequent traveler card. It needs to be understood that the card type is also important, because not every frequent traveler card holder is entitled to use the premium security pass. For instance; a basic card would only allow passenger to earn points for their flights without any extra services while a platinum, elite, or premium card would allow passengers and to their travel companions to receive extra service in airline/airport lounges, priority check-in and boarding and so on as well as flight points. Security officer makes sure that the passenger have been checked- in to his/her flight by controlling the boarding pass. Then he/she checks the ID and compares the name with the credentials written on the boarding pass and the frequent traveler card. Lastly, officer checks the card type, to grant access to the gates through premium line security point. There have been cases where this rather lengthy control process offset the value that is to be presented to the premium passengers. In addition; this lengthy visual ID control process is repeated at least three times during a passenger's time at the airport. It is also crippling the organizational efficiency as it is not a flexible process. Following section, explains the expectations from a possible solution that aims to streamline the control process and turns it into a high-end service for premium passengers by using the latest technologies. It also presents the potential for this solution in other daily operations at Helsinki Airport.

4.1.2 Expectation and Possibilities

In the context of this study the primary expectation is to prove the concept which suggests that face recognition and wearable devices are indeed beneficial in ID management in the airport environment. In order to fulfil this expectation the proposed solution should prove that the visual ID check up's have been made simpler, faster and more convenient for the both user and the passenger at the end of the study. A smart glass reinforced with the face recognition capability will work towards this goal by eliminating the redundancies in the process at the Premium Line Security Pass point. Below figure illustrates the part of the process that this solution is aiming to improve.

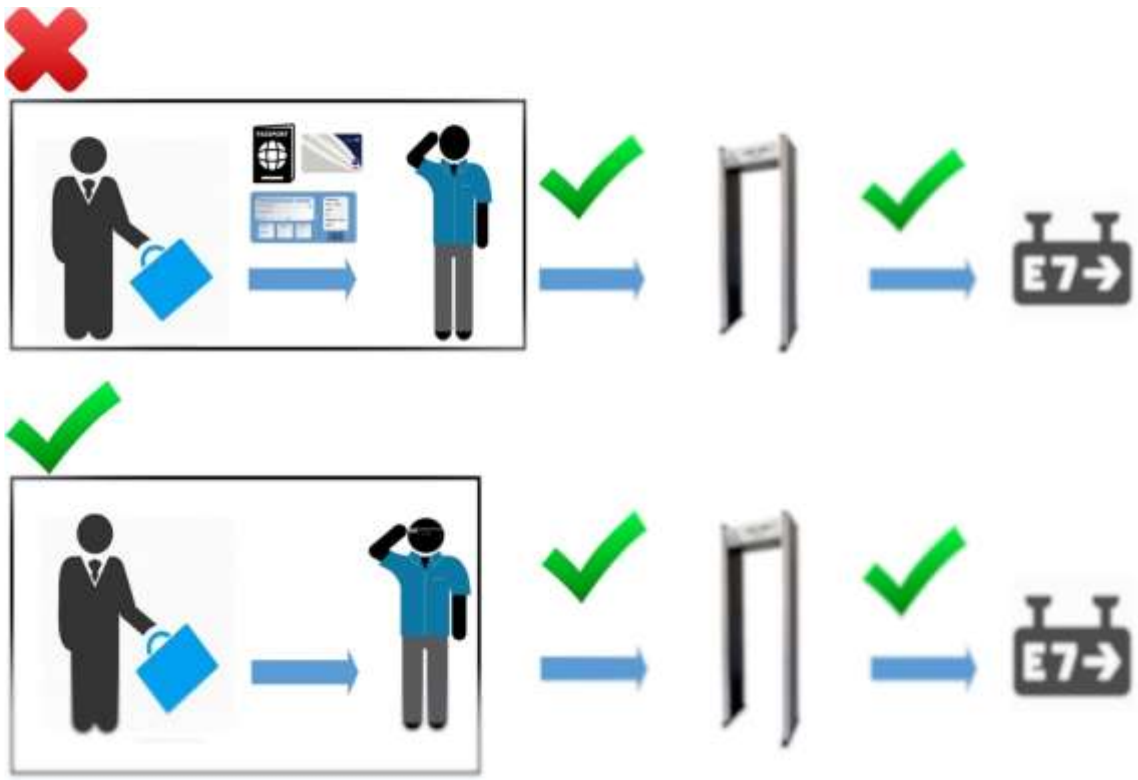

Figure 14. *Old and new visual ID check-up process.*

As illustrated in the figure above the proposed solution aims to save valuable time of premium passengers by utilizing the smart glass and the face recognition capability. The solution suggests that the passengers face and relevant card details, including card type will be registered to the system prior to trip to the airport. The check-in information will fed to the system whenever the check in is completed, thus, removing the necessity to show the boarding pass. A premium passenger will not need anything but her/his face to use the premium line security pass at Helsinki Airport.

However, in in areas like airports where security concerns are extremely high, there are additional requirements for a solution to become feasible. A flaw in the system that would allow someone to hack into would give anyone to access restricted areas. In addition, since privacy sensitive data of the passengers will be restored in the database, an unauthorized access is unacceptable. Security of the system and safety of the data are among the key expectation Finavia OYJ. In the following chapter, measures taken to tackle these challenges are explained in detail.

Although this study is limited to the services and processes at the Premium Line Security Pass, once the concept is proven there are many possibilities for improvement in other areas, using the same technology. It is already underlined this study aims to prove the concept in order to pave the way to the IATA's vision of future passenger experience. Therefore, this first step is only a small part of a value chain that is to be achieved when the concept is proven and the value proposition is validated at the end of this study. The following steps of the project can be achieved in parallel to aforementioned Helsinki Airport Development Program. The same solution can be put to the service of passenger at the Helsinki Airport in key airport operations to provide complete value as shown in the figure below.

***Figure 15**. Key Airport operations adopting the same technology till 2020*

The launch for the Premium Security Pass point is June 2016. If the solution brings the promised benefits the technology could easily be adopted in the lounges at the Helsinki airport for the year business class passenger. Adopting face recognition technology at the check-in and boarding would be a ground breaking initiative although it has been visioned by IATA in the year 2013. Therefore, full adoption of this technology in these areas might take until 2020 as it would require a lot of financial and human resources.

Next section explains the implementation of the proposed solution. The design elements technical improvements are illustrated as well as the impacts made process wise. It also evaluates outcomes of the overall implementation.

4.2 Implementation

After idea is generated to address the problems stated by both the researcher and Finavia OYJ, both parties came together to clarify the objectives of the project. Objectives are gathered under three different drivers of the change: service quality, security and operational efficiency. The aim was to determine objectives that would serve as a solution the aforementioned problems in the short run while producing results that would align with Finavia's expansion strategy for the year 2020. The objectives of the project are listed below.

Figure 16. Objectives of the project

Firstly, service quality has been prioritized by both the researcher and Finavia OYJ. The current airport technologies would not allow airport operators to differentiate the services between regular passenger and premium customers of the airlines. Therefore; the service primarily aims to reduce the time that frequent flyers spent for the ID check-ups at the Helsinki Airport.

Secondly, the technology inherently comes with its perks in other areas even though the efforts are focused on the service quality. Security is one of the areas. Whenever a new security measure enforced at the airports, passengers are forced to either spend more time at the security points or required to show extra effort. Adopting this technology will surely add up to the security as manual identification process will be abandoned, hence, human error will be minimized without causing extra inconvenience to the passengers. Finally, one of the objectives of the project was to example how operational efficiency can be enhanced through the use of face recognition and wearable devices. In addition to instant identification ability thanks to face recognition, wearable devices enable users to communicate instantly which is expected to immensely improve the operational efficiency.

In order to achieve the goals and objectives stated above, project plan was created by the researcher, estimating 8 months of work. Tasks and roles, aligned with the project plan, were clarified and delegated for the contributing parties of the project. Researcher, Finavia OYJ and the 3rd party code developer are the parties in the scope of this research. Researcher, naturally, claimed the major share of the work whereas Finavia OYJ had facilitator role as illustrated in the Figure 17 below.

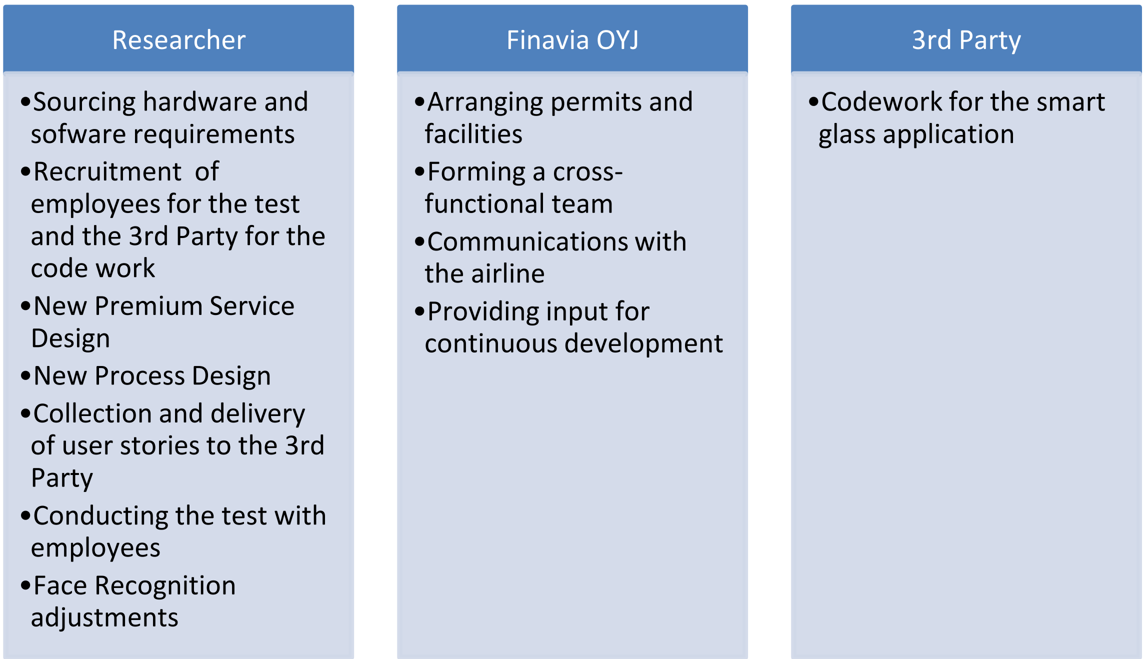

Figure 17. Task and roles shared between parties of the research

In order to fulfill the tasks and roles in a structured manner a project team established that was led by the researcher. Finavia OYJ provided the relevant employees for the cross functional team. The team divided into two sub-teams, technology and business team, in order to ensure the relevancy of task to members of the sub-teams. The 3rd Party android app developer and the face recognition SDK supplier placed in the technology sub team Airline kept in the loop throughout the project and their opinion taken into the account. The structure of the team is illustrated in the Figure 18 below.

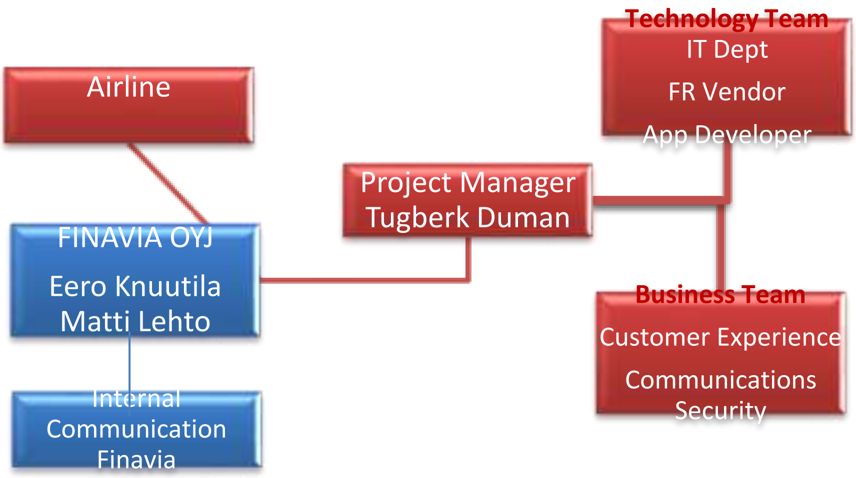

Figure 18. Structure of the Project Team

The initial task for the team was to start the sourcing process, in both hardware and software side. A Japanese company was selected as the supplier of the face recognition SDK while Google was decided to be the designated hardware. Researcher's previous experience with the supplier and the hardware has been a factor during decision making. Finavia management was made aware about each major decision by the researcher. Airline that was a selected prospective partner for the continuation of the project after the research was kept knowledgeable about the developments by Finavia Management. Before going to passenger context, it is decided to test the technology with the employee where exposure is less and damage control is possible. Employee security checkpoint 2 was chosen as the test location. Under the light of aforementioned set of decisions, researcher's tasks, role and methods to fulfill certain tasks were further clarified, as presented in the Table 4 below.

Table 4. Criteria, method and brief outcome for the *researcher's tasks.*

Researcher Task	Criteria	Method	Outcome
Recruiting Employees for the test	A Minimum of 100 employees needed	Questionnaire Face to Face Recruiting	32 from Questionnaire + 80 from face to face recruiting
Service Design	The research must serve as groundwork for the new premium service that would be adopted airport-wide	Observation	App made compatible for the new premium experience and can be adapted in other areas such as boarding, check-in lounges.
Process Design	A digitalized process instead of the old paper based one	Observation	Necessary Information fetched from the face recognition server and displayed to user by the Glass.
User stories	An app with a simple UI that allows only authorized peopled to make recognitions	Observation Interviews	One-step login module integrated in order to reach identification module
Face Recognition Adjustments	Reaches to the industry standard of %90 minimum match rate (i.e. face match score)	Employee Tests	Adjustments were made in the database to reach %95+

The project continued with the development of the prototype after studying the requirements of the premium pass security point. Initial test were held with the employees at the employee security checkpoint 2. During the development & test agile software development method has been followed. Implementation process completed in 8 months, completing the application that is developed in accordance with the requirements of the premium security pass. However, within the given deadline test and launch of the application at the designated location was not possible. In the Figure 19 below, the timeline for the implementation of the technology is illustrated.

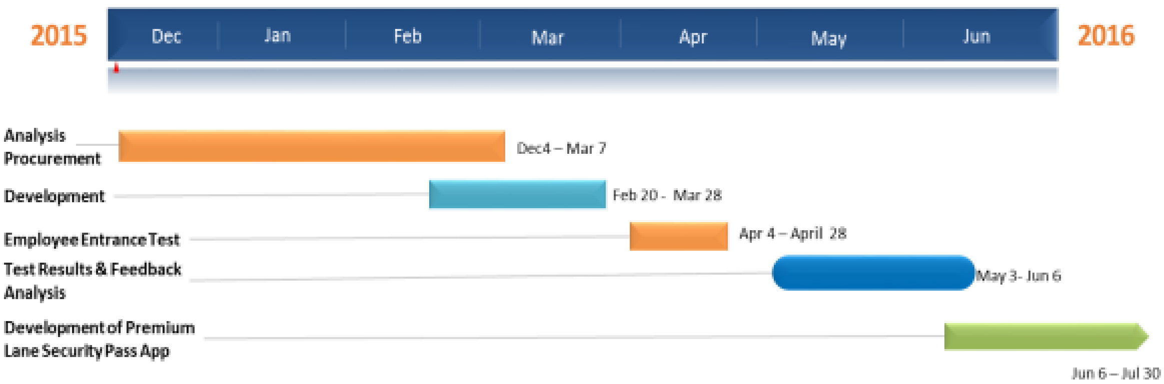

Figure 19. *Implementation timeline.*

Next sub-section explains the development and test process from technical point of view. It is followed by more procedural point of view and chapter finishes by the evaluation of the technology in technical, procedural and commercial sides.

4.2.1 Technical Improvements & Design

Prior to development process, the working principle of the employee security check was analyzed. Photos are sourced from the ID database of the airport for voluntary employees who wanted to take part. After receiving initial requirements and days of observations at the premium pass security point and security checkpoint 2, three design criteria determined by the researcher:

- UI needs to be as simple as possible
- Google Glass' role must be reduced to minimum to avoid latency and overheating
- Only authorized personnel should be able to use the application

First of all, when it comes to the cutting edge technologies that is not yet a commodity for the common public, simplicity is the key. Referring to the previous experiences on glass and studies on the innovation management, the complexity that comes with the Glass must be offset with the simplicity of the UI. Therefore; researcher designed a three step user interface and each steps follow the other automatically without any involvement from the user. Figure 19 below explains the working principle of the UI.

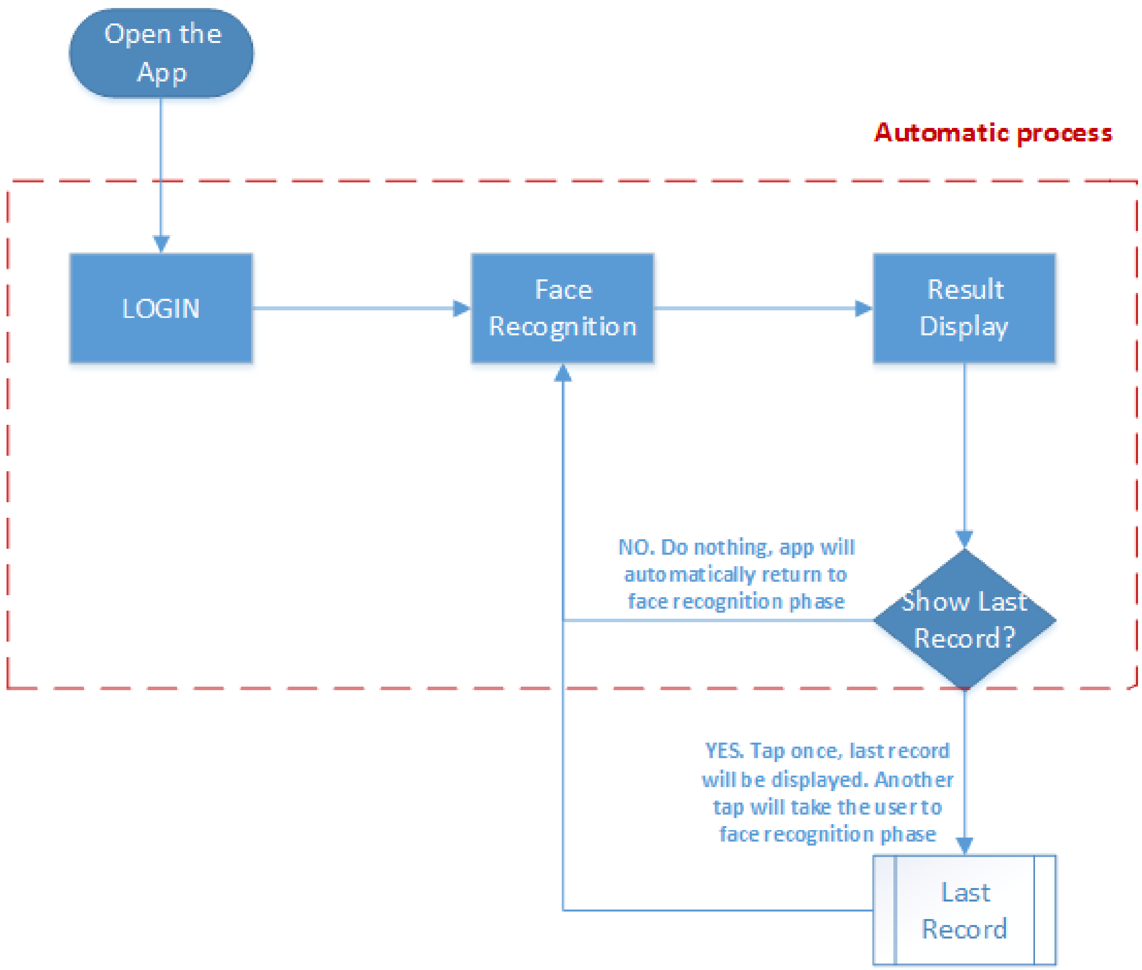

Figure 19. *UI architecture*

The design illustrated in the figure above allows user to use the application without actively involving in the process with a touch or voice command. When the specific task of the step is completed (e.g. successfully recognizing a face) system will take the user to the next step automatically. User needs to command only when opening the application for the first time, or when he/she wants to see the last record after a recognition.

Second, due to previous experiences with the Glass and with the lessons from the previous literature, researcher concluded that Google Glass' role needs to be kept minimum to avoid overheating and latency which will result in low performance. This was done by outsourcing all the computing task to a remote server and using the Glass as a record & display tool to capture the probe images and send them to face recognition for comparison with the reference image saved in the database. This ensured longer battery life, maximum efficiency, less latency and overheating. The working principles of the back-end is illustrated in the figure 20 below.

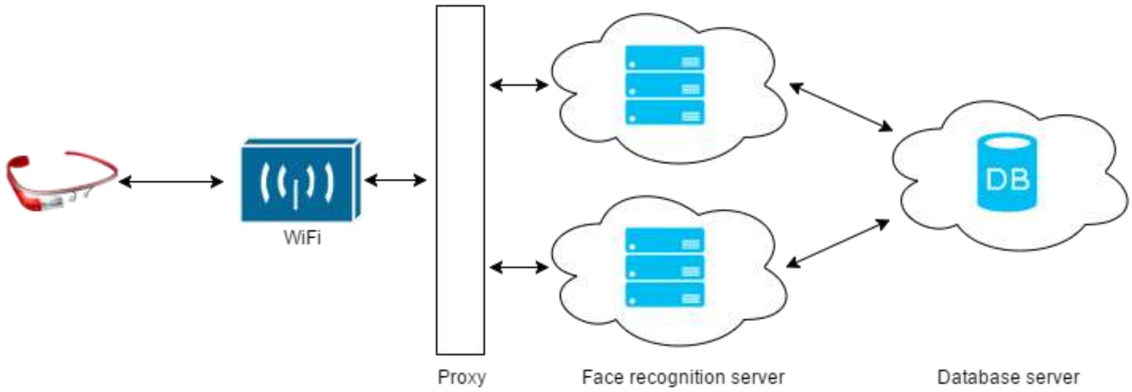

Figure 20. *Back-end architecture.*

After the back-end and user interface architecture designed, they were delivered to 3rd party application develop with the user stories. Due to privacy issues involved and the need for high security, application divided into two modules. First module enables an authenticated user to login to the system and this grants access to the second module – identifications of the employees/passengers. The login and identification module is explained in the Table 5 below with the actual vision of the user through the Glass display.

Table 5. Login and Identification Module

An authorized user would be able to use the photo on the ID card to s login the system	
If the user is registered, the application will show their name. The login can be performed by using the **Tap** gesture. .	
After the login was performed, the face recognition screen is shown (see picture to the right). By simply looking at the face in front, the face will be recognized.	
If the face was successfully recognized, the name of the person will be visible for 5 seconds.	

After user successfully logged into the system, the identification module will automatically start running as shown in the above. The user interface is designed to be as simple as possible and the need for active interaction between the user and device is minimized.

Face recognition, as explained in the literature part, is another key component for the proposed system. It gives scores between 0 to 1 (i.e. %0 to %100) that indicates the likelihood of the face that is being recognized and the face that is stored in the database. This is called the match rate. In order to avoid false negatives and false positives it was important to determine the optimum acceptance rate, which is, in other words, the minimum accepted match rate.

Throughout the tests (i.e. employee entrance test) that took place at security checkpoint 2 with employees; controlled experiments took place to find the optimal settings for face recognition. The tests took three weeks, and each week there were 4 days of tests and 3 days of development with the feedback received from the users. In this context, users refers to the security personnel at the airport who otherwise checks the identity of the employees by looking at the ID cards. The tests took two hours on the days the tests were scheduled. Researcher was present during those times collecting instant feedback on UI, Google Glass and face recognition performance. Apart from the instant feedbacks and researcher's own observations, four of the six users were interviewed for overall feedback and further development.

The interviews with the users showed the significance of knowing the quality of the recognition also known as the match rate of a particular recognition. To upgrade the system performance and to enhance the user experience, several improvements made during and after the test period. These improvements aimed to increase the robustness and reliability of the system. However, the trade-off between the latency in data transfer and the accuracy of the recognition made has been challenging. The table below summarizes the problems observed during the test as well as the user feedbacks during the interviews.

Table 6. İmprovements in the system and design throughout employee entrance tests.

Problem	**UI or Face Recognition Side?**	**Fix**
Camera keeps running although there is no one to recognize	User Interface	Stand By Mode Activated after 50 seconds
I can only see the last record of the recognition I made	User Interface	Last 3 recognition record made available to the user by a tap gesture.

The face recognition score can vary dramatically because of a momentarily change in gesture, illumination etc.	Face Recognition	Three recognition request send to server before displaying the result to the user.
The low quality of the photos taken by the Glass and used for face recognition requests, decreases the match rate.	Face Recognition	The quality was set to maximum, significant increase in the match rate has been observed. However, sizeable data traffic caused latency at times.
The quality of the face recognition should be made available to the user	User Interface	The results that have above 0.9 match rate marked with green whereas between 0.85 and 0.9 marked with yellow. Anything below 0.85 was not accepted.

The user interface was reinforced with the new features that were considered must for the passenger context. In the passenger context, additional information needed to be displayed to the user, such as frequent flyer card type. Next chapter explains how adoption of this technology changed several practices and process in identification of passenger at the airport.

4.2.2 Process Changes

This pilot project is the first step towards fully digitalization identification services for premium Passengers that would lead to boarding-pass free travel, at the airport. Therefore, as this is a completely new way of passenger identification wherever it is necessary, current processes are not compatible with the requirements of this technology. This technology has been tested with the employees at an employee security checkpoint in Helsinki Airport. The previous identification process at that point was requiring at visual & electronic check of the ID card which usually corresponds to the boarding pass at the premium security pass point - the desired test place in passenger context. When passengers do not drop by the airport check-in counter or do not have the appropriate eligible to use mark in their boarding pass, they are also asked to present their frequent flyer card as well as an ID. The information sharing has been mostly manual between the check in counter and premium security pass point, provided by boarding pass. The similarity of the technologies and the methods between passenger and employee identification allowed researcher to design the new process for the requirements of premium security pass, although it could be put in use during the research.

Although, pilot scope was limited to premium security pass point, the aim was to eliminate the need for a boarding pass and minimize time spent for visual id check-up. The most important change in the whole process takes place in the very beginning. Also this is where the value proposition is made. A frequent flyer card holder is asked to register himself with a facial picture to the system through sources provided by the airport operator and the airline, instead of having to introduce himself every time when he/she uses premium security pass point. Below table summarizes the differences between the new and old visual ID check-up process.

Table 7. *Old processes versus new ones.*

Process	***Old Process***	***New Process***
Registration	Not required	Card information with a facial picture need to be registered. (once & only before the first visit)
Document Control	Provided by **passenger** with a Boarding Pass, ID, Frequent flyer card (at each visit)	Provided by the **face recognition system** at the security point. Necessary information is attached to Face info saved in the database.
Check in info	Provided by **passenger** with a boarding pass	Provided by the **face recognition system**. Information fed to the system after check-in is completed. User sees the info through Glass display when the recognition is done.

By registering themselves for one time before the first visit to airport, frequent flyers cardholders has been granted the privilege to simply walk through the premium security pass point without having to show anything to the security personnel as required information is displayed to the user instantly after each successful recognition.

4.2.3 Evaluation

There are many key issues that needs to be evaluated before making a major decision to adopt this kind of technology as the primary visual identification method at the airport.

Each key component of the technology must be reliable and robust enough to produce the desired performance. The major component of the technology is the face recognition software. There are only handful of researches that studies the use of face recognition software with smart glasses as explained in the Chapter 2.2.4. As seen in the cases, the main focus was determining and improving performance of the Glass, rather than the performance of the face recognition. However, in the airport context reliability of the face recognition performance when it comes to granting access only to authorized people is crucial. The main criteria for the face recognition system in this research was the acceptance rate, in other words the minimum match rate.

When the number for acceptance rate set right, false negatives (i.e. rejecting access of an authorized person) or false positives (i.e. granting access to an authorized person) is automatically avoided. During the testing process, on 08.04.2016 CEO, the face recognition sdk supplier stated the following explaining the optimal acceptance rate for their product:

> *"...our product is capable of achieving %85 acceptance rate for surveillance, %90 for passport images and %95 for access control with a stationary camera. These numbers are proven to be high enough to prevent the false positives."*

In the scope of this research, the proposed solution was a digital access control method. Therefore; the aim was to reach the industry standard of %95 acceptance rate. However, a smart glass enables both sides of the recognition to be mobile which was expected to be a challenge. In order to determine the case specific optimal acceptance rate controlled experiments took place at the security checkpoint 2. To test the limits of the face recognition system, 900 random photos added to the database. System was expected to successfully fetch the pre-registered 112 photos among the 1012 ones stored in the database. A total of 2068 face recognition request made by the Google Glass within 3 weeks of time. 1693 of the 2068 request made in the first two weeks of tests. It was important to separate the genuine face recognition request with those unreliable ones. Genuine face recognition request refers to a deliberate action of the user in order to recognize the face in front whereas an unreliable request could happen anytime as application keeps running and tries to make recognition of the faces around all the time. Therefore; the researcher rejected any recognition attempt that resulted below 72% match rate upon studying the log file. The results are illustrated in the table below.

Table 7. *Test Statistics for the first two weeks from the log file.*

Genuine Face Recognition Requests	Acceptance Rate	False Positive	False negative	Accurate Recognition/ Percentage
319	85%	11	56	252 / 78%

The initial results were not matching the standards in terms of neither achieved acceptance rate nor the recognition percentage as illustrated in the table above. However, the results were promising considering the fact that face recognition systems require strong database which require at least four to five photos when it comes to access control. CEO of the face recognition sdk supplier confirmed that with the following statement:

> *"…in order to achieve the suggested acceptance rate the database should at least have four or five photos for each individual."*

Upon further study of the log file, it became clear that, the similarity between the photo stored in the database (i.e. reference image) and the photo used for the face recognition request (i.e. probe image) provides a significant increase in the match rate. That is why, database was strengthened with additional photos as illustrated which made positive impact on the match rate. The phenomenon explained in the Table 8 below.

Table 8. Face Recognition Accuracy depends on the similarity of the photos stored and photos used for each face recognition request.

Parameters	**First two weeks of tests**	**Last week of tests**
Photos in the database		 
Photo taken by the Glass and used for face recognition request		
Match Rate provided by the server	**%78 - %89**	**%97+**
Acceptance Rate set by the Researcher	**%85**	**%95**

As illustrated in the table above when the reference image and the probe image are not similar there are matches that remain below the acceptance rate –meaning the system would produce a false negative. In other words; an entitled person would be granted with the access which has been the case with 56 attempts in the first two weeks of the tests. If the acceptance rate is decreased in order to avoid false negatives, false positives increase accordingly. This means granting access to an authorized person which is out of question in security sensitive place like airport.

The last week of the tests were conducted with this lesson in mind. As it was impossible to collect additional photos from all the employees who took part, a small group of employees including the researcher agreed to add an extra photo in the database. The test were conducted recognizing the aforementioned member of the groups in different times at the security checkpoint 2. The results for these test were also gathered in a log file as illustrated in the Figure 21 below.

Figure 21. *Caption of the face recognition log file.*

The red rectangle in the picture above highlights the match rate after the database have been strengthened with similar reference and probe images. The system started produce to reliable and consisted results as seen in the table above. Table 7 summarizes the system performance after the improvement of the database.

Table 7. *Test Statistics for the first two weeks from the log file.*

Genuine Face Recognition Requests	Acceptance Rate	False Positive	False negative	Accurate Recognition/ Percentage
145	95%	0	1	144 / 99%

It was proven that only when similarity of the photos in terms of illumination, background is increased system becomes reliable enough to be used in airport environment where security is a top concern. Combining with the hardware performance, the system, reliability wise proven as feasible when correct adjustment are made during two hours long testing. However, battery, latency, over heating issues emerged from the hardware side after two hours. Hardware issues are discussed in detail in the following chapters in comparison to previous researches and cases. The value added by the project is also evaluated in the following chapter from the stakeholder's point of view.

5. LESSONS LEARNT

This chapter aims to provide objective insights looking at the outcomes of the project. The first section elaborates on the value added by this study in the light of aforementioned implementation objectives and goals. Each and every endeavor that aims the change through cutting edge technology comes with someone foreseeable challenges as well as the unforeseeable ones. This challenges can be on the organizational side as well as the technical side. Second section of this chapter explains the challenges experienced by the researcher.

5.1 Value Added

Value added in this project can be evaluated in two categories – functional and psychological value. To speed up the visual id check-up process, increasing the automation at the premium security pass point were the major functional values that this study promised. In the scope of this study the aim was to develop a proof of concept. In order to prove the feasibility of the proposed system a single and simple airport operation was chosen. Before putting the application in use in the passenger context, test with employees were conducted in a location under similar conditions. After the tests, interviews took place with the users and the people who agreed to be recognized automatically. Automation of even a minuscule part of the airport operations provided with a potential increase in the operational efficiency. A security screener who was one of the users for the test period stated the following on the interview that took place on 14.04.2016:

> *"…use of the Glass became easier each time I used it. I have an open mind towards face recognition through smart glass as the ID check method at the airport. Since the person can look really different from their ID photo, a recognition made by the face recognition system can be more accurate than a recognition made by human eye."*

In addition to the functional value, potential psychological value has been shown to both parties, Finavia OYJ and the people who have been involved in the tests. Being recognized, without having to introduce themselves or hand over an ID has been a major value point for the employees. As the product could not be tested with passengers during the project timeline, the positive feedback from the employees would be the reference for a similar passenger reaction. An interviewee, who works on the expansion project of the airport and uses the employee security checkpoint 2 frequently, stated the following on the interview that took place on 14:04:2016

> *"...I have applied to take part through the questionnaire. I believe, being recognized without having to introduce yourself is the future, and anything that makes security screening easier is necessary."*

In airport operator's perspective; it was a major source of differentiation in terms of identification services considering this is one of the first endeavor in this area. Eero Knuutila, Head of the Service Development at Finavia OYJ confirmed this value during a meeting that was held on 06.06.2016:

> *"...As the technical feasibility of technology is proven, the next step would be to test it at the relevant areas of the airport to provide boarding pass free travel to our premium passengers. Thereafter; it is a big differentiation and PR for the company."*

As the project scope was limited to a small airport operation, the potential value that it would bring still to be exploited. However, as seen in the testimonials of the people who have been involved in the process, the project proved that it has potential as the outcomes were found promising. Table 8 below, summarizes the value added by the project, considering the feedback received from the employees and the Finavia Management. The feedback from employees used as a reference to determine the potential value to the premium passengers, as the idea and the main benefits are similar.

Table 8. Value Added by the project.

Stakeholder	Functional	Psychological
Finavia Oy	• The information sharing streamlined at the premium security pass • The groundwork has been completed for adopting the technology in other airport operations	• It has been a major source of differentiation comparing to services of other airport operators and served as a PR campaign.
Premium Passengers (in reference to employee feedback)	• The need for handing over documents has been eliminated • Visual ID check-up made easier	• Being recognized, without introduction

As summarized in the table above the technology needs to be widely adopted to offer to provide chain of functional value. However, as proof of concept it successfully lay the groundwork for future implementations. In addition to that, it has been proven that physiological value that is added by the technology is as important as the functional value.

5.2 Implementation Challenges

Considering the fact that project aims to be the pioneer in its area, there have been challenges which delayed the implementation process. One of the most natural challenge that we anticipated was the resistance to change. Resistance, in this case, was fueled by skepticism towards the reliability and feasibility of the solution at the beginning. As this was an endeavor to support or even replace the current airport technologies which has remained almost the same over the last decade, some of the airport employees and other stakeholders were skeptical. As the solution proposes the use of emerging technologies such as smart glasses and face recognition, the skepticism grow due to lack of awareness. However, once the reliability and robustness of the solution is proven after the initial test, skepticism was replaced with interest and encouragement.

Privacy concerns, has been one of the major challenges and over which people needed to be convinced. This concern appeared in both passenger side and employee side. A major airline that operates in Helsinki Airport clearly stated their concerns on using cameras on public places to recognize people could be associated with violation of privacy. People often confused the technology with constant surveillance and recognition of their faces at the airport. Researcher needed to take time explain that area and purpose of use limited to points where security control is being done at the airport.

In organizations this scale, it is was seen that response rate and speed can be low as well. As the project requires many departments to collaborate, arranging meetings that gather each concerned employee at once has been difficult. In addition; people working on multiple projects and having their own understanding on the priority of the matters slowed down the progress.

Apart from organizational & communicational challenges there have been technical challenges as well. Connectivity to the cloud was essential for whole system to work. However, the designated place for the test was in minus first floor where connectivity through data package was impossible due to low reception. The airport Wi-Fi was working, but as Google Glass is not able to confirm and connect through a landing page that was not an option. The problem is solved when Finavia Information Management department created a private network that allows connectivity without confirmation through a landing page.

Due to the fact that this was only a proof of concept, a cloud based server was used throughout the pilot in order to keep the cost low and minimize the interference with the physical airport systems. This made the system vulnerable to the drops in the internet speed, and increase in the data traffic at a particular time. At that times latency is increased, especially when three recognition attempts was necessary. Natural reaction was to reduce the number of recognition request in case in the first attempt the match rate given was below the acceptance rate. However, as this would have been compromising from the accuracy, the challenge remained throughout to project timeline and is expected to be removed when a private network with physical servers are utilized instead of a low-cost cloud based solution.

As mentioned before, the photos are sourced from the employee database. This photos were taken when the employees first admitted to the job. For some employees the photos were more than six year old. Growing old is a natural source for the change in someone's face. Also change might occur when gaining or losing significant weight, using prescription glasses and so on. Although the system can tolerate this kind of minor changes, to increase the reliability of the system, it should be fed with up to date images of the employees and the passengers.

Another unforeseeable challenge was the problem caused by the cases where there is a significant difference in height between the Google Glass user and the person whose face was to be recognized. The face recognition software is able to provide matches up to thirty degrees of angle. However the match rate is naturally decreased when this is the case – usually beyond acceptance rate which makes it an unacceptable result. There is no natural solution to this problem especially in the scope of this project. Users were asked to reduce to height gap to the acceptable levels by moving their body accordingly. In addition to that when both parties of the transaction is mobile, change in the pose, and the gesture (e.g. laughing) affected the quality of the output. Table 10 below summarizes the challenges explained so far.

Table 10. Implementation Challenges.

Challenges	Organizational &Communicational	Technical	Human Error
	Skepticism	Connectivity	Difference in Height
	Privacy Issues	Server Type	Change in the pose
	Respond Time & Rate	Using old photos as the reference image	Change in the gesture

Due to being first in the area project faced with several challenges as summarized in the table above. As a proof of concept attempt with rather limited scope, only a part of the challenges has been solved throughout the project timeline. Others left for future researches. This subsection concludes the empirical part of this study. Next chapter will discuss reflecting on the learnings from literature and empirical researches. The models introduced in the literature part is re-investigated to see how they were utilized in the empirical part of the research.

6. DISCUSSIONS

This thesis has focused on developing a proof of concept for new identification methods and services through cutting edge technologies at the airport. To be more specific, this refers to the use of face recognition to develop an application for smart glasses which identifies the frequent flyer card holders wherever identification is necessary.

With the main objective of providing an inconvenience-free experience to the premium passenger at the Helsinki Airport, the necessary elements studied in the light of previous literature, observations and interviews conducted at the airport. The focus has been reliability and the robustness of the technology as well as the commercial value for the passenger and the service provider. The findings were in parallel with one of the most articulated problem in the previous researches. As many scholars pointed out, lack of customer involvement has a significant adverse effect on the NSD projects. Although the NSD model of Alam & Perry (2002) that emphasize the customer involvement has been adopted, lack of the timely & sufficient involvement from the customer groups prevented project to fully complete its objectives. The three customer groups that were originally planned to take part in the NSD development are listed below:

- Internal customers (i.e. employees)
- Airline
- Passengers

First, the input of internal customers has been utilized thorough the entire development process. The department that the input came from varied according to the stage at the model. For example, in the strategy planning phase, input came from the service development department whereas in service & process design required input from security department as well. Their involvement have been rather straightforward an easy-to-access compared to other two customer groups.

Second, a major airline which was thought to be a customer of the end product kept informed about the project progress. The aim was to utilize their input in the NSD model as well. However, it became clear that the reliability and the robustness of the project needed to be proven, before receiving an input as the value proposed through these unorthodox technologies was unclear. After reliability and robustness of the technology has been proven the discussion has been started. However it was already late in the project timeline which was just not enough to take the project to the passenger context. Finally, passengers as the main benefactor planned to be included in NSD. Their input were important the tailor the scope and extend of the new service exactly in parallel to their needs. However, due to delay in actively involving airline and their passengers their input could not be utilized as effectively as planned during the timeline of this project. Table 11 below illustrated the input that come from various customers during different phases of NSD.

Table 11. *Customer input during the NSD Process*

NSD Process	Internal Customer Input	Airline Input	Passenger Input
Strategy Planning	The need for the use of cutting edge technologies emerged as the expansion plan for 2020 revealed.	Differentiation of the services for premium passengers has been the main strategic goal.	X
Idea Generation (*Idea generated by the researcher*)	X	X	Premium Passengers indicated their dissatisfaction with the airport's and airline's ability to offer distinguished services
Idea Screening	Shaping the idea to be used at the Premium Security Pass	Feasibility of the technology needs to be proven	X
Business Analysis	Proof of concept needs to be developed before adopting the technology which could ensure the profitability	Commercial value could be achieved through chain of service that are utilizing the idea	X
Cross Functional Teams	Researcher joined by a team of professional on purchasing, marketing security and service development	A contact person remotely kept updated with the progress	X

Service Design and Process System Design	Initial design made according to inputs from security personnel as it needed to be tested before going to passenger context	X	X
Personal Training	Delivery of the service by the security personnel was observed	X	X
Service Testing & Pilot Run	Feedbacks collected from the employees used in final improvements on the app	Further concerns and improvements for the passenger context were discussed after the positive test results	X
Test Marketing	*Left for Future Studies*	*Left for Future Studies*	*Left for Future Studies*
Commercialization	*Left for Future Studies*	*Left for Future Studies*	*Left for Future Studies*

As explained in the table above NSD model was taken as the guide throughout the research. However, limitations, challenges and the delays experienced throughout project refrain the development to go further in the NSD model stages.

One of the important discussion would be the areas of use in the future. Even though technology was founded technically feasible and can indeed be implemented in the premium pass point, the significance of perceived value of the implementation from the passenger point of view remained questionable. It is important to go further in the NSD model with the active involvement from the customer to determine the possible areas of use to create value chain that would lead to the boarding pass-free travel. Figure 16 of Section 4.1.2 could serve as roadmap in terms of timeline and the areas of use in the illustrated order.

The second part of the literature was concerning the technology development that would be used in the service to be developed. Google Glass was the designated hardware and hence it was studied thoroughly. Through the observations of the researcher and the interviews made with the users; some features of the Glass proven to be extremely useful which are highlighted with green in the Table 8 below. On the other hand; as pointed out in the previous researches, some issues have indeed been challenging. Those issues highlighted with yellow are relevant to the scope of this project. The researcher also noted the potential challenges - which are highlighted with red - that can be experienced if the scope of project expanded. Those that are not highlighted considered irrelevant to the scope of the project now and in the future.

Table 12. *Google Glass Evaluation (Adapted from previous researches)*

Hardware	**Area of Use**	**Features**	**Issues**
Google Glass	Consumer	Easy to operate, hands free use	Price
	Tourism	POV Camera	Battery
	Culture	Touch Voice Gesture Command	Privacy Issues
	Medical	Internet Connection	Lack of Applications
		Sleek outlook	Commercial Availability

The sleek outlook of the Google Glass and the fact that it is designed to be used in consumer and tourism sectors had utmost importance for this project as the hardware put in use at an airport. The hands free use of the Glass enabled the users to interact with the employees freely. Point of view camera, constant data transfer via internet connection has been among the highly appreciated features of the glass. On the other hand, the high usage of these two features caused battery to run out fast, requiring recharge in every two hours. Considering that major airports run 7/24, battery issue limits the areas of use for the Glass. In addition, the Glass requires a google account to start working which communicates with all other Google products such as Google+. Therefore, it was important to make sure that any confidential information was not being published online. It is the most important challenge that the project team has tackled as without ensuring the security of the data transfer the project would not have gone forward. If the project scope will be expanded by adopting technology in other areas, lack of commercial availability and the high price determined by the 3rd party sellers might reduce the chance of the Glass as the designated hardware for the future.

7. CONCLUSION

This chapter concludes this research and summarizes the findings. Objectives that are set in the beginning are compared against the outcomes of the research Touchpoints that could not be included in this research as well as improvements through future research are discussed in this chapter.

7.1 Meeting Objectives

The research intended to develop a proof of concept for face recognition and smart glass for identification services at the airport. The initial target group was premium passengers of the airlines, namely frequent flyer card holders and business class passengers. Target group chosen considering the fact that this new premium service would distinguish loyal and high spending passenger from regular passengers, which is not possible otherwise with the current airport technologies.

Apart from offering exclusive services to premium passengers, there are operational benefits for airport operators by adopting the technology. The ever increasing need for security, and the growing demand for air – travel which forces airports to expand their physical capacities were the main touchpoints where the technology could provide additional benefits. Considering the aforementioned drivers, three main objective for the project determined in collaboration of Finavia Oyj aligned with the expansion strategy for 2020. These were:

- Inconvenience-free identification process for Frequent flyers
- Minimizing the human error caused by manual ID check process
- Maximizing the operational efficiency through instant Identification and Communication

First and foremost, the technology needed to prove that it is able to remove inconveniences such as the need for showing documents to pass the identification point. The documentation of concern could be boarding pass, passport or id card and, frequent flyer card. Second, the technology aimed and accuracy rate which would outperform the manual identification process. False identification due to fatigue, lack of concentration is a known phenomenon at the airports. Finally, the technology was expected to demonstrate that operational efficiency can be increased through the instant communication and information sharing between devices databases and employees.

It was important for Finavia to ensure the reliability and the robustness of the technology, before proceeding to passenger context as both component of the technology have not established themselves among the common public. Two weeks of test conducted and the project found reliable and robust as explained in the previous chapter. The summary of the learnings were as follows:

- The minimum accepted match rate can go as high as %85 even with one photo per-person database
- False rejections are minimized to %5 and false positives are eliminated
- The average recognition speed was 1 second
- Any information can be attached to the reference image and displayed user

Considering the implementation challenges explained in the previous chapter, the technology was found promising especially after removing the limitations which had crippled the overall performance. The system was further improved by implementing the feature which registers the photo (i.e. probe image) that is used in each face recognition request if the number of photos that are registered under that particular person's name is below seven. Under the light of the learnings and further improvements, some of the objectives met in theory and practice whereas others met only in theory as the technology could not be put in to use in passenger context during the timeline of the research as explained in the Table 11 below.

Table 11. Objectives Summary

Objective	The extend that the objective was met	Explanation
Service Quality	Proven that face recognition is a fast & feasible way for identification and removes the need for presenting additional document.	The system could not put into use at the security point during the research.
Security	It was shown that human error would no longer be a factor after false rejections are eliminated through increasing the number of photos per person.	It was not possible to gather more photos of the participants during the research.
Operational Efficiency	Insights were provided as to how Instant communication between devices, databases and employees would impact operational efficiency.	As a proof of concept, the number of devices, databases and servers were limited to one.

As explained in the table above due to limitations and short of time, the research served as a groundwork in meeting the objectives. There are touchpoints that were included in the plan of his research. Next sub-section explains the nature of future researches that need to be made to build on the findings of this research. The touchpoint that could not be addressed in this research are also discussed in the next subsection.

7.2 Limitations and Implications for Future Research

Despite meeting the objectives to the extent explained in the previous chapter, this study was subject to some limitations that affect its validity. First of all, the literature review did not address exactly the same issue studied in the thesis. Partially this is because of the increasing but still novel interest about using unorthodox technologies such as smart glasses and face recognition for new service development. While there were previous studies that addresses the new service development through customer collaboration, there were no previous studies that addresses specifically cases where the end product is a cutting edge technology on which customers (e.g. frequent flyers card holders) have no or little knowledge about. Studies that refer to B2B customer – service provider collaboration cannot be utilized to the fullest either since contribution of a B2B customer (i.e. major airline) has been also extremely limited. It was challenging to find specific cases addressing the main interests of the study in terms of new service development. On the technology side, it was also challenging the cases that uses smart glasses to recognize faces in an operations of this scale and importance.

Secondly, the number of people that allowed their faces to be used in the test remained low. It was only around hundred employees signed up among the potential 400. This hampered the aim of simulating a lifelike situation as there were minutes of breaks between two recognitions which will not be the case when the technology is adopted. In addition; as the time allocated for the study was not enough to conduct tests in passenger context, empirical data remained limited to result of the test with the employees as well as the feedback collected from them after the tests.

Further research could include more thorough empirical study by involving the passengers and the airlines to fully analyze the viability of the technology both in commercial and technical side. The challenges that were left for further studies could be analyzed in order to provide suggestions to overcome them. It became clear that, sourcing reference mages, is an important first step for a feasible identification application that is to be used at the airport. Therefore, integrating an image sourcing app to the current app could be the next step to provide technically and commercially viable solution to the airlines, and to the passengers.

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APPENDIX A: EMPLOYEE RECRUITMENT QUESTIONNAIRE

1) What is your age? Ikänne? *

2) Gender? Sukupuolenne? *

3) Your duty? Työtehtävänne? *

4) How many times a day do you need to show/use your work ID card for access? Kuinka monta kertaa päivässä joudutte käyttämään ID korttianne kulunvalvonnassa? *

5) Have you ever used your biometrics (finger print, eye recognition etc) as personal identification? / Oletteko ennen käyttäneet biometrisiä tunnistuskeinoja (sormenjälki, verkkokalvontunnistus yms.) *

6) Have you heard of smart glasses such as Google Glass? Oletteko kuulleet älylaseista kuten Google Glass? *

7) How would you feel if your colleague/friend start using it around you? Mitä pitäisitte jos kolleganne/ystävänne alkaisi käyttämään sellaista kanssanne *

8) Would you be interested in using it yourself to assist you with your work at the airport? Käyttäisitkö mielelläsi älylaseja työskennellessäsi? *

9) Do you use prescribed glasses for eyesight problems? Käytättekö silmälaseja näkövaikeuksien takia? *

10) Which smart glass would you rather use? Mitä älylaseja mieluiten käyttäisitte? *

11) Would you allow us to use face recognition to minimize (to 1 second) the time you spent at all security points? Antaisitteko meidän käyttää kasvontunnistusta minimoimaan ajan (1 sekuntiin), jonka käytätte kulunvalvonnassa? *

12) Would you like take part in this project and tell your grandchildren that you were one of the first people to try this technology in Europe? Haluaisitteko osallistua tähän projektiin ja kertoa lapsenlapsillenne olevanne ensimmäisiä, jotka kokeilivat tätä teknologiaa Euroopassa? *

13) If you answered 'yes' to one of the last two questions please leave your name and email address, we will contact you shortly! Jos vastasitte 'kyllä' jompaan kumpaan viimeisistä kahdesta kysymyksestä, jättäkää nimenne ja sähköpostinne ja olemme teihin pian yhteydessä!

14) If you said 'No' to last two questions, please let us know why / Jos vastasitte 'ei' kahteen viimeiseen kysymykseen, kertokaa miksi.

15) If you have any feedback please feel free to share, your opinions matter! Voitte kaikin mokomin antaa palautetta aiheesta, mielipiteellänne on väliä!

APPENDIX B: EMPLOYEE INTERVIEWS

User Interface:

1) How difficult was it for you to use the application? Would you want add/remove/ change anything?

2) Do you think recognition time (the time you start looking at employee’s face until the result is displayed) was convenient?

3) Were the results accurate? Have you had any false positives?

4) How was your experience with the Google Glass?

5) 4) Do you have any additional comments?

Overall Feedback

1) How do you feel about using face recognition as an access method at the security point?

2) Could this technology be utilized in passenger context? If so, where?

3) Do you think of any other are at the airport that the technology could be useful?

4) Do you have any additional comments?