DESIGN OF A WEARABLE FOR USE IN AN AIRCRAFT CABIN

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SUMMARY

The aim of the bachelor assignment was to create a wearable for use in an aircraft cabin, offering valuable functionalities to the user. In this context, a wearable can be defined as a computing device worn on the body. The purchaser of the assignment was *Zodiac Aerospace*. *Zodiac Aerospace* develops aerospace equipment (*Zodiac Aerospace, n.d.)*. The company aims for constant innovations in its businesses and has three branches: *Zodiac Cabin*, *Zodiac Seats*, and *Zodiac Aerosystems ('Graduation opportunity', n.d.)*. Besides developing new equipment, the products are also manufactured by the company (*Zodiac Aerospace, n.d.)*. *Zodiac Aerospace* has two business strategies.

The first one is *Buyer Furnished Equipment* (BFE) and the second one is *Supplier Furnished Equipment* (SFE). The former includes the sales of equipment that is selected by the buyer of the aircraft, the airline, or the leasing company and the latter includes sales of equipment selected by the aircraft supplier, that is, the manufacturer of the aircraft. The company is focused on niche markets *(De Beco, 2016)* and wants to develop products which 'rapidly acquire a leading position' *(De Beco, 2016)*. Since the market of wearables is still at its beginning, *Zodiac Aerospace* could indeed acquire a leading position in that market.

In the beginning of the assignment, the target group and the problem to be solved were open. Therefore, research on the potential target group as well as on existing wearables has been done. The research on the target group included interviews that were hold with some flight attendants, interviews with some pilots, and a survey about passengers' experiences on board of an aircraft. After this, it was decided that pilots are not a suited target group for the bachelor assignment, since they do not have any problems which might be solved by a wearable.

However, there still were some possibilities left to design a product. The first one was to design a device that helps to prevent the spread of illnesses on an aircraft. The second possibility was to design a wearable that helps people to overcome their nervousness about flying. The third idea was to design a device that helps passengers to improve their sleeping behavior during a flight; and the last idea was to design a wearable for the cabin crew. Since the interviewed flight attendants claimed to only have a few minor problems during a flight, it has been critically searched for potentials to create a wearable for them during the next phase of the project.

Hence, in the next phase, more detailed information on the four ideas mentioned before has been looked up and it was brainstormed for solutions. For the device to be used by the cabin crew potentials for functionalities were examined based on wearables that already have been tested on an aircraft, the scope of duties of a flight attendant as well as problems that sometimes occur, both obtained from the interviews. After the concept ideas were generated, it was decided to go on with the idea to design a wearable for the cabin crew. As a next step, this idea has been more worked out to become a full concept and also the kind of the device has been chosen. The devices that were considered at first were *Google Glass*, *Microsoft HoloLens*, and a smartwatch. The device that has been chosen is the smartwatch. It was decided to design an own smartwatch that could be developed by Zodiac Aerospace. By developing an own device, it can be ensured that the product is designed in exactly the way how *Zodiac Aerospace* wants it to be.

The last step was to examine solutions for the functions of the device and additionally, to design the looks of the device. The functions of the designed smartwatch are:

1. Not fastened seat belts or open bins must be highlighted.
2. The device must inform the flight attendants if and where a drink or meal is available when it is lacking in the corresponding trolley.
3. The device must provide flight attendants with information on the flight, workshops and emergency cases.
4. The device must provide flight attendants with information on that someone made an order and who ordered what when passing their seat.

The first function is realized by integrating sensors into the passenger seats and the bins. When a passenger is not wearing his seat belt or a bin is still open, the system recognizes this and informs the flight attendants which seats need to be checked.
For the second function, when an item is lacking in a certain trolley, the flight attendants can check where a certain meal or drink can be replaced by using an application on the smartwatch. In order to do so, the flight attendants can open an application on their device called *stock inspection*. On the screen they can then choose between *drinks, meals,* and *other* and then they can choose the corresponding item. Then, it is displayed where the item can be replaced.

The third function is meant for the unlikely event that there is an emergency on board and a flight attendant has a blackout, so that he or she does not know what to do. Then, it can be looked up what to do in a database. To do so, the flight attendant opens the application *database*, searches for a certain keyword or selects a certain chapter form the application's menu.

To realize the last function, the device informs the flight attendants about orders that have been made by displaying a text message. When the orders are prepared, the items need to be handed out. It is unnecessary for the flight attendants to remember who ordered which item thanks to the smartwatch. The smartwatch shows the location of the corresponding flight attendant and the location of the passengers who ordered something on its screen. Additionally, when arriving at a passenger who made an order, the device vibrates and displays the seat number and which item has been ordered on the screen.
To conclude, using the device helps to perform the procedures mentioned before more efficiently and the service is improved. Therefore, the wearable does not only offer valuable functionalities to the user but also to the passengers. Orders are served faster and an eye is kept on the compliance of safety instructions.

The design of the smartwatch is simple and functional. The screen is bigger than those of other smartwatches on the market to ensure that the displayed text can be read more easily. For a comfortable fit, the wristband is also wider than usual. Additionally, the bottom side of the smartwatch is slightly curved to adapt to the form of the wearer's wrist. Moreover, the size of the wristband can be adjusted so that the device is universal.
Another important aspect during the design process was to design the product in such a way that the wearers as well as the people who get in contact with them feel comfortable. Since the

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device is worn on the wrist and the passengers recognize when and how the device is used, in opposition to smart glasses, it is not daunting for them.

Of course, the company's goal is to earn money with the product. This can be done by selling or leasing the smartwatch to airlines. The device is interesting for the airlines since it helps to improve the passenger experience and it also makes the work of the flight attendants more convenient.
Right now, the device is designed to have four different functions. In the future, it is possible to expand the range of functions. For inspiration for new functions, observations of the work of flight attendants could be made and interviews with a larger number of flight attendants could be executed.
Additionally, user tests should be made. It should be tested if the cabin crew enjoys working with the device and if they are satisfied with its handling. Moreover, passengers could also be asked how they experience the service when flight attendants are using the device.

Also, for manufacturing, a material and the production technique must be chosen. Additionally, it must be checked which supplier is going to deliver which materials and parts, and what the estimated costs are.

SAMENVATTING

Het doel van de bacheloropdracht was om een wearable te ontwerpen voor het gebruik in het vliegtuig, welke waardevolle functies biedt voor de gebruiker. In deze context kan een wearable gedefinieerd worden als een computer die op het lichaam gedragen wordt. De opdrachtgever was *Zodiac Aerospace*. *Zodiac Aerospace* ontwikkelt luchtvaartapparatuur (*Zodiac Aerospace, n.d.)*. Het bedrijf streeft naar constante vooruitgang in zijn business en heeft drie afdelingen: *Zodiac Cabin, Zodiac Seats* en *Zodiac Aerosystems ('Graduation opportunity', n.d.)*. Naast het ontwikkelen van nieuwe apparatuur worden de producten ook vervaardigd door het bedrijf (*Zodiac Aerospace, n.d.)*. *Zodiac Aerospace* heeft twee business strategieën: d e erste is *Buyer Furnished Equipment* (BFE) en de tweede is *Supplier Furnished Equipment* (SFE). De eerstgenoemde omvat de verkoop van apparatuur die door de koper van het vliegtuig, de luchtvaartmaatschappij of de leasemaatschappij is geselecteerd en de laatstgenoemde omvat de verkoop van apparatuur die door de vliegtuigleverancier gekozen is, dat wil zeggen de fabrikant van het vliegtuig. Het bedrijf is gericht op nichemarkten en wil producten ontwikkelen die snel een leidende positie verwerven *(De Beco, 2016)*. Aangezien de markt van wearables nog steeds aan het begin is, kan *Zodiac Aerospace* inderdaad een leidende positie op die markt krijgen.

In het begin van de opdracht waren de doelgroep en de probleemstelling open. Daarom is er onderzoek gedaan naar de potentiële doelgroep en naar al bestaande wearables. Het onderzoek naar de doelgroep omvatte interviews met een aantal piloten en stewardessen en een enquête over de ervaringen van passagiers aan boord van een vliegtuig. Daarna werd besloten dat piloten geen geschikte doelgroep zijn voor de bacheloropdracht omdat ze geen problemen hebben die door een wearable opgelost kunnen worden. Er waren echter nog enkele mogelijkheden om een product te ontwerpen.
De eerste was het ontwerpen van een apparaat dat helpt bij het voorkomen van verspreiding van ziektes in een vliegtuig.
De tweede mogelijkheid was om een wearable te ontwerpen die mensen helpt om hun zenuwen over vliegen in bedwang te houden.

Het derde idee was het ontwerpen van een apparaat dat passagiers helpt om hun slaapgedrag tijdens een vlucht te verbeteren. En het laatste idee was het ontwerpen van een wearable voor de stewardessen. Aangezien de geïnterviewde stewardessen aangaven slechts een paar kleine problemen te hebben tijdens een vlucht, is er onder andere kritisch gezocht worden naar mogelijkheden om een wearable voor de stewardessen te ontwerpen tijdens de volgende fase van het project.

Dus, in de volgende fase is er gedetailleerde informatie over de vier eerdergenoemde ideeën opgezocht en werd er gebrainstormt over mogelijke oplossingen. Voor het apparaat dat door de stewardessen gebruikt zal worden, zijn er potentiële functionaliteiten onderzocht. Hierbij is er gekeken naar wearables die al getest zijn in een vliegtuig, de taken van een stewardess, en de problemen die soms optreden. Deze informatie is gehaald uit de interviews met de stewardessen.Nadat de concept ideeën ontwikkeld waren, werd besloten om verder te gaan met het idee om een wearable voor de stewardessen te ontwerpen. In de volgende stap werd dit idee meer uitgewerkt tot een volledig concept en ook het soort apparaat werd gekozen. De apparaten die eerst overwogen worden zijn *Google Glass*, *Microsoft HoloLens* en een smartwatch. Het apparaat dat gekozen werd is de smartwatch. Er werd besloten om een eigen smartwatch te ontwerpen die door *Zodiac Aerospace* ontwikkeld kan worden.

SAMENVATTING

Door een eigen apparaat te ontwikkelen, kan er gewaarborgd worden dat het product precies op de manier ontworpen is hoe *Zodiac Aerospace* het wil.

De laatste stap was het uitwerken van oplossingen voor de verschillende functies van het apparaat en bovendien het ontwerp van het uiterlijk van de smartwatch. De functies van de ontworpen smartwatch zijn:

1. Niet aangelegde veiligheidsgordels of open bakken moeten worden gemarkeerd.
2. Het apparaat moet de stewardessen informeren of en waar een drankje of maaltijd beschikbaar is wanneer het in een bepaalde trolley ontbreekt.
3. Het apparaat dient informatie ter beschikking te stellen voor de stewardessen over de vlucht, workshops en noodgevallen.
4. Het apparaat moet de stewardessen erover informeren dat iemand een bestelling gemaakt heeft en wie wat besteld heeft bij het passeren van hun stoel.

De eerste functie wordt gerealiseerd door sensoren in de passagiersstoelen en de bakken te integreren. Wanneer een passagier geen veiligheidsgordel draagt of een bakje nog steeds open is, herkent het systeem dit en informeert de stewardessen erover welke plaatsen gecontroleerd moeten worden. Voor de tweede functie, als een product in een bepaalde trolley ontbreekt, kunnen de stewardessen controleren waar een bepaalde maaltijd of drank vervangen zal kunnen worden door een applicatie op de smartwatch te gebruiken. Hiervoor kunnen de stewardessen de applicatie op hun apparaat openen, genaamd *stock inspection*. Op het scherm kunnen ze dan kiezen tussen *drinks, meals* en *other* en dan kunnen ze het gezochte product kiezen. Vervolgens wordt er op het scherm weergegeven waar het product vervangen zal kunnen worden.

De derde functie is bedoeld voor het onwaarschijnlijke geval dat er een noodsituatie aan boord is en een stewardess een blackout heeft zodat hij of zij niet weet wat er gedaan moet worden. In dat geval kan de stewardess dan de juiste instructies opzoeken in een database. Om dit te doen opent de stewardess de applicatie *database* en zoekt een bepaald onderwerp op of kiest een bepaald hoofdstuk uit het menu van de applicatie. Voor het realiseren van de laatste functie informeert het apparaat de stewardessen over de bestellingen die gemaakt zijn door een bericht weer te geven. Als de bestellingen voorbereid zijn, moeten ze worden uitgedeeld.

De stewardess hoeft niet te onthouden wie welk product besteld heeft dankzij de smartwatch. De smartwatch geeft de locatie van de stewardess weer en ook de locatie van de passagiers die iets besteld hebben. Bij aankomst bij een passagier die een bestelling gemaakt heeft, trilt het apparaat en geeft het stoelnummer en het bestelde product weer. Concluderend helpt het gebruik van het apparaat bij het efficiënter uitvoeren van de eerder genoemde procedures en ook de service wordt verbeterd. Daarom biedt de wearable niet alleen waardevolle functies voor de gebruiker maar ook voor de passagiers. Bestellingen worden sneller geserveerd en er wordt gekeken of de veiligheidsinstructies op de juiste manier gevolgd worden.

Het ontwerp van de smartwatch is simpel en functioneel. Het scherm is groter dan bij andere smartwatches op de markt om ervoor te zorgen

dat de weergegeven tekst gemakkelijker kan worden gelezen. Voor een comfortabele pasvorm is de polsband ook breder dan normaal. Bovendien is de onderkant van de smartwatch iets gebogen om zich aan te passen aan de vorm van de pols van de gebruiker. Daarnaast kan de grootte van de polsband worden aangepast, waardoor het apparaat universeel is. Een ander belangrijk aspect tijdens het ontwerpproces was om het product zodanig te ontwerpen dat de gebruikers en de mensen die in contact komen met hen zich prettig voelen. Aangezien het apparaat op de pols gedragen wordt en de passagiers herkennen wanneer en hoe het apparaat gebruikt wordt, in tegenstelling tot smart glasses, is het niet afschrikkend voor hen.

Natuurlijk is het doel van het bedrijf om geld te verdienen met het product. Dit kan gedaan worden door de smartwatch aan de luchtvaartmaatschappijen te verkopen of te verhuren. Het apparaat is interessant voor de luchtvaartmaatschappijen aangezien het helpt bij het verbeteren van de passagierservaring en het het werk van de stewardessen makkelijker maakt. Op dit moment heeft het apparaat vier verschillende functies. In de toekomst zal het mogelijk zijn om dit uit te breiden. Ter inspiratie voor nieuwe functies kunnen observaties van het werk van de stewardessen helpen en ook zal er een interview met een groter aantal stewardessen uitgevoerd kunnen worden.

Daarnaast zal het handig zijn als er gebruikerstests uitgevoert worden. Het zal getest moeten worden of de stewardessen graag met het apparaat werken en of ze tevreden zijn met de bediening van het apparaat. Bovendien is het mogelijk om passagiers te vragen hoe zij de service ervaren als de stewardessen het apparaat gebruiken. Verder moet er voor de fabricage nog een materiaal en de productietechniek worden gekozen. Daarnaast moet gekeken worden naar welke leverancier welke materialen en onderdelen levert en wat de geschatte kosten zijn.

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INTRODUCTION

Zodiac Aerospace

The purchaser of the bachelor assignment is *Zodiac Aerospace*. *Zodiac Aerospace* develops aerospace equipment (*Zodiac Aerospace*, *n.d.)*. The company, which is the world leader in its sector, aims for constant innovations in its businesses. Its 'technological expertise is based on three core business lines: comfort and life on board aircraft, onboard systems, and safety on the ground and in-flight' *('Graduation opportunity', n.d.)*. These 'are grouped into three branches: *Zodiac Cabin*, *Zodiac Seats*, *Zodiac Aerosystems*, supplemented by the dedicated after-sales business of *Zodiac Services*' *('Graduation opportunity', n.d.)*. Besides developing new equipment, the products are also manufactured by the company (*Zodiac Aerospace*, n.d.). *Zodiac Aerospace* has two business strategies. The first one is *Buyer Furnished Equipment* (BFE) and the second one is *Supplier Furnished Equipment* (SFE). The former includes the sales of equipment that is selected by the buyer of the aircraft, the airline or the leasing company and the latter includes the sales of equipment selected by the aircraft supplier, that is, the manufacturer of the aircraft. The company also offers after-sales service to its clients.

Aim

The development principles of *Zodiac Aerospace* are diversifying into high technology business areas, focusing on niche markets, supporting customers and ensuring steady growth in earnings per share *(De Beco, 2016)*. Hence, *Zodiac Aerospace* wants to develop products which 'rapidly acquire a leading position' *(De Beco, 2016)*. Therefore, the aim of this bachelor assignment was to create a wearable for use in an aircraft cabin, offering valuable functionalities to the user. In this context, a wearable can be defined as a computing device worn on the body. The market of wearables is still in its infancy, but it develops very fast. Nevertheless, there are barely any wearables that are especially meant for use in an aircraft cabin, so that *Zodiac Aerospace* could indeed acquire a leading position in that market.

Reader's guide

The target group of the product that has been designed is the cabin crew. However, in the beginning of the assignment, the target group and the problem to be solved were open. Therefore, in chapter one, the analysis phase, two important research questions are answered: 'Can the product to be designed build upon existing technologies?' and 'Who could be the target group and what are the needs and problems of the target group during a flight?'. In order to answer the first question, a market research on existing wearables has been done. For answering the second research question, research on the potential target group has been done by interviewing pilots and flight attendants as well as conducting a survey with potential passengers.

The result of the first chapter are four new research questions, which are answered in chapter two. The first question is: 'How can the spread of illnesses on an aircraft be prevented?'. This question is answered by taking a closer look on the background of the spread of illnesses and on antibacterial materials. The second question, 'How can a passenger overcome his nervousness about flying?', is answered by looking up background information on fear of flying and treatment methods.

The third research question is: 'How can sleeping behavior on an aircraft be improved?', and it is answered by doing research on methods to improve sleep quality and existing products

which help to improve sleep quality. The last question is: 'What are potential functionalities for a device for the cabin crew?'. For answering this question potentials were examined based on wearables that already have been tested on an aircraft, the scope of duties of a flight attendant as well as problems that sometimes occur during their work.
After this, it was chosen to go on with the idea to design a wearable for the cabin crew. The relevant questions which are answered during the elaboration of the concept are: 'Which functionalities are valuable for a wearable to have?', ' How could the functionalities be realized?', 'Which device is suited to perform the functionalities?'. After answering these questions, it was chosen to detail a range of functions for a smartwatch.

In chapter three the smartwatch is detailed by answering the following research questions: 'Which functions should the smartwatch have?' and 'How can these functions be realized?'.

ANALYSIS PHASE

1.1 INTRODUCTION ANALYSIS PHASE

In order to achieve the aim to create a wearable for use in an aircraft cabin which offers valuable functionalities to the user and ensures *Zodiac Aerospace* a leading position in the market of wearable technology for aircrafts, the possibilities on the functions for such a wearable as well as the suited target group needed to be examined.
The questions which are answered in this chapter are 'Can the product to be designed build upon existing technologies?' and 'Who could be the target group and what are the needs and problems of the target group during a flight?'.
The first question is answered in paragraph 1.2 by executing a market research.
First, it has been done research on wearables in general and second, research on wearables that were tested or are actually used in an aircraft environment, such as the aircraft cabin or the airport, was done.
This subdivision is done in order to get an overview of all the possibilities to develop functions for a wearable device as well as to get inspiration on functionalities which are specifically meant for the use on an aircraft. Not all of the wearables on the market are mentioned in the market research. Most devices have similar functions and many others are not relevant for the assignment. Therefore, only the devices which might be interesting in the course of the project are mentioned.

To answer the second research question, research on the potential target group has been done in paragraph 1.3. During this research, pilots and flight attendants were interviewed and a survey with potential passengers was conducted.

1.2 MARKET RESEARCH

1.2.1 WEARABLES IN GENERAL

Smart glasses

There are a few smart glasses that all have similar functions. Smart glasses are hands-free devices that some of them can be voice-controlled. They might also have a *facial recognition* function. By making use of augmented reality (AR), smart glasses can provide the wearer with information on his environment. Also smart contact lenses might be available in the future *(K Toh, 2016)*.

A product example for an advanced smart glass is the *Mini Augmented Vision (figure 1.1)*, developed by *BMW*. The device is a combination of head-up displays and smart glasses and enables the viewer to have an all-round view of the environment outside the car. By using AR, warnings, speeds, and navigation can be projected in front of the driver's eyes. This device is controlled via buttons on the steering wheel *(K Toh, 2016)*.

Figure 1.1: Mini Augmented Vision

Smart clothing

Currently there are various wearable technologies available or under development that fall into the category of smart clothing. 'Smart fabric is made of fabrics and conducting wires, integrated circuits, LEDs, and conventional batteries. Data is transmitted via Bluetooth (...)'
(K Toh, 2016).
Such clothes can store and manipulate data; they might be able to display images, text or video and are connected to the internet.

In this category are some important product examples. The first one is electronic fibers which can detect disease and radiation, control the release of pesticides, kill bacteria, and capture hazardous gases. These electronic fibers have been developed by the *Cornell University* in New York and might be commercially available in the future *(K Toh, 2016)*.

Another interesting product is the *Cuddle Jacket (figure 1.2)*. It has been developed for psychological and therapeutic uses, since it assists children with sensory disabilities. For instance, autistic children are likely to get stressed under pressure, when hearing loud sounds, or by meeting new people. The jacket can measure the vital signs

1.2 MARKET RESEARCH

of the wearer and can calm him when needed. By using deep pressure therapy, stress can be eased *(K Toh, 2016)*.

Two other products that might be interesting for this assignment are a jacket that can be plugged into an *IPod* to navigate the song lists and a multi-tool jacket *(figure 1.3)* that has especially been developed for air travelers. The multi-tool jacket has some built-in features such as an inflatable neck pillow, an eye mask, and utility pockets for gadgets of various shapes and sizes *(K Toh, 2016)*.

Figure 1.2: Cuddle jacket by T.Ware

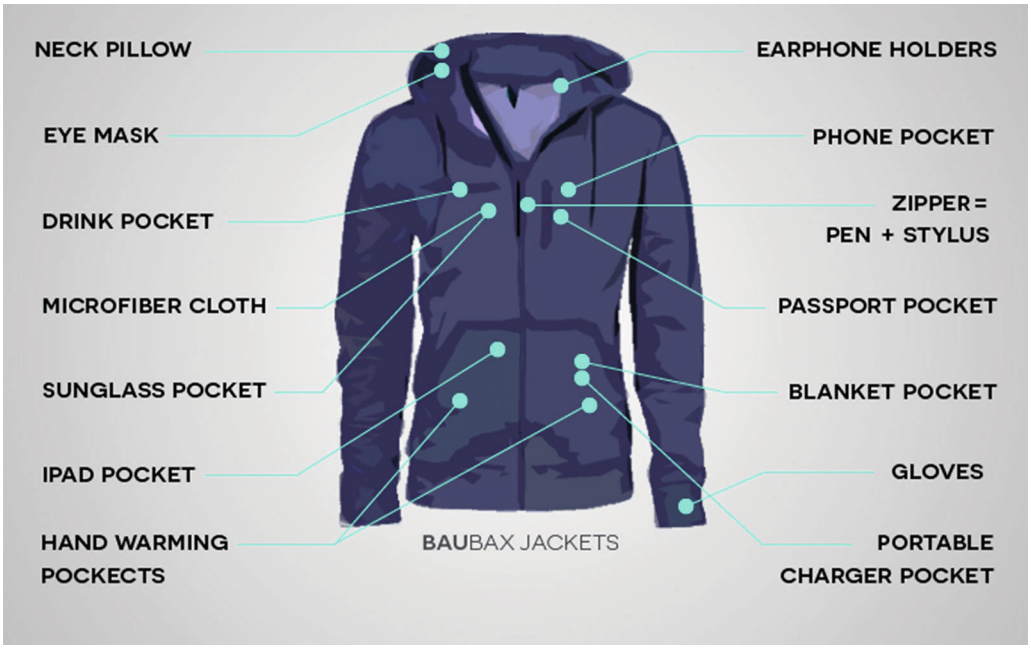

Figure 1.3 Baubax multi-tool jacket

Smartwatches

Smartwatches are worn on the wrist and they incorporate some or most features of a smartphone. They have a display on which they inform the wearer about incoming calls, notifications, the weather, the time and similar information. The user might also be able to make calls and send messages with a smart watch. Additionally, by managing the settings, the user can enable the watch to filter the information he receives. Most smart watches only work in combination with a smartphone *(K Toh, 2016)*.

Sports and fitness devices

Sports and fitness devices monitor the wearer's physical activity, sleep habits and other biological functions, including inputs, states, and performance. 'At their most basis, activity trackers monitor steps, most track sleep habits, sophisticated ones include heart rate sensors, some can tell the difference between different kinds of activities such as swimming, running or biking. The complete range of tracking activities includes calories, steps, distance, duration, heart rate, and sleep. The leading styles of fitness gadgets are wristband, clip-on, and chest strap'
(K Toh, 2016).

A few fitness devices also alert the user when someone is calling and many also have voice support or even voice control. Most available products are not standalones, so they only work in combination with a smartphone.

Two product examples are the *Jawbone UP3* and the *Dash earbuds (figure 1.4)*. The former is a band worn on the wrist that also includes bioimpedance sensors which measure the resistance of tissue and blood flow from the wrist. In combination with skin and ambient temperature sensors the device can provide a more comprehensive picture of the wearer's activity level. The latter, the *Dash earbuds*, are so called 'hearables'. Hearables are wearables residing in or on the ear. Next to their function as a fitness tracker and heart rate monitor, the earbuds function as music player and headphone. *Dash* also provides supplemental information on the people the user meets and the places the user visits *(K Toh, 2016)*.

Figure 1.4: Dash earbuds

1.2 MARKET RESEARCH

Healthcare devices

A healthcare device is used to diagnose, prevent, or treat disease or other health conditions. Wearable healthcare devices have the potentials to improve healthcare, save lives and reduce costs. While some wearable medical devices can be implanted, others are worn on the body and they handle a range of functions. External devices can, for instance, monitor vital signs, assist the movement of artificial limbs, and collect and transmit physiological data. Implants might control heart rhythms, monitor hypertension, stimulate nerves, monitor bladder and cranial pressure, or operate as glaucoma sensors.

By using wearable healthcare devices, a doctor could be alerted when there is something wrong with the patient. He might also check on the patient's health at any time. There are also devices that can detect whether an elderly patient has taken a fall and some can remind the user to take his medications *(K Toh, 2016)*.

1.2.2 WEARABLES FOR USE IN AN AIRCRAFT ENVIRONMENT

Microsoft HoloLens

The *HoloLens (figure 1.5)* invented by *Microsoft*, is a smart glass that uses AR. It projects images directly into the wearer's field of vision. The device has been tested by *Japan Airlines* for the training of engineers as well as crew members. They see possibilities in developing new training methods, since training without the *HoloLens* depends on the availability of jets. Instead of using textbooks to show students the various engine parts, the *HoloLens* can be used to show students the inside of any engine and they can also interact with the engine without opening up a real aircraft *(Neuner, 2017)*.

Figure 1.5: Microsoft Hololens

Apps for Apple Watch and Sony Smart Watch

EasyJet and *British Airways* have created apps for the *Apple Watch (figure 1.6)* for storing boarding passes and receiving real-time updates *(Neuner, 2017)*.

The airline *Virgin Atlantic* has a partnership with *Sony Smart Watch* to improve the customer service. The watch can be used for storing boarding passes and receive information on the upcoming flight *(Nguyen, 2015)*.

Figure 1.6: Apple Watch

Figure 1.7: Google Glass

Figure 1.8: Epson Moverio BT-200

Smart glasses for flight attendants and pilots

Smart glasses could be used for a more personalized passenger experience, since they could provide information on the guests to the staff through *facial recognition (Neuner, 2017)*.
For instance, *Virgin Atlantic* used *Google Glass (figure 1.7)* to test how wearable technology can enhance the passenger experience and improve efficiency. By providing information on the passengers, the staff was able to greet them by name and to see their travel history *(Nguyen, 2015)*.
There are not only smart glasses which can be used by the cabin crew or the ground staff, but there are also smart glasses for pilots. Product examples are *Aero Glass* and *Epson Moverio BT-200 (figure 1.8)*. *Aero Glass* provides information on navigation, air traffic, and current weather and it brings AR to pilots by providing an unparalleled 3D experience. The *Epson* smart glass includes a GPS system, a compass, an accelerometer, a camera and can also provide information on the flight *(Nguyen, 2015)*.
Another scenery in which smart glasses might be useful is the manufacturing of an aircraft. *Accenture* and *Airbus* developed a smart glass for helping operators to improve the accuracy of assembling seats and to minimize the reqired time for the assembly *(Howard, 2015)*.

Wearable data from Skyzen

The *SkyZen* app for passengers enables the user to monitor his health and wellbeing before, during, and after a flight. It is used in combination with a *Jawbone* fitness wristband. By also entering information on the flight, the app can overlay the fitness data and the flight data to provide insights for flight and jetlag management *(Neuner, 2017)*.

1.2 MARKET RESEARCH

Kokoon headphones

Kokoon developed sleep sensing headphones *(figure 1.9)* that could be used to improve the sleeping behavior of passengers during a flight. The headphones track the user's sleep and can be used as regular headphones. They adjust the volume of the music when the user is sleeping or when there are surrounding noises. Additionally, they are quite comfortable so that the user can wear them while sleeping without any problems *(Neuner, 2017)*.

Figure 1.9: Kokoon Headphones

Smart uniform

EasyJet created a smart uniform *(figure 1.10)* in cooperation with the label *CuteCircuit*. The uniforms have integrated LED lights as well as sensors and a microphone. The built-in microphone improves the communication between the engineers, the cabin crew and the pilots. Additionally, the LEDs of the flight attendants' uniforms display the flight number as well as the destination and they provide light in cases of emergency. The uniforms of the engineers have built-in air quality sensor and a barometer for monitoring the engineer's work environment *(Nguyen, 2015)*.

Figure 1.10: Smart Uniform

Guardian Mentor Remote

The Australian aerospace company *TAE* is planning to commercialize *CSIRO's Guardian Mentor Remote* (GMR), shown in *figure 1.11*. GMR uses a headset and glasses to connect the operator with experts for assistance in real-time. This might be great for engine repairs since the expert does not need to be at hand but can provide assistance via the GMR *(Wearable Technology Insights, 2015)*.

Figure 1.11: Guardian Mentor Remote

Happiness blanket

British Airways designed the *Happiness Blanket (figure 1.12)*.The blanket works in combination with a headband embedded with sensors and measures the satisfaction of the wearer. The level of satisfaction is then monitored by using LEDs that are woven into the blanket. Depending on the mood, the blanket glows in a certain color. For instance, when a person is anxious, the LEDs glow red. The *Happiness Blanket* helps the airline to investigate how the passengers' relaxation and sleep is affected by various aspects on board *(Miller, 2014)*.

Figure 1.12: Happiness Blanket

1.3 TARGET GROUP RESEARCH

To determine the target group of the product, research has been done on the problems occurring during a flight which potentially could be solved. To find out what the functions of the wearable could be, it was important to gain insight into the general struggles of the people in an aircraft cabin.
The people that are on board of an aircraft are the flight attendants, the pilots, and the passengers; therefore research has been done on potentials to develop a wearable for all of them.

To identify the problems of the staff, it was first necessary to gain insight into their scope of duties. Therefore, interviews were conducted with three pilots as well as with three flight attendants. Since most of the questions were about the tasks that need to be carried out before, during, and after the flight, it was not necessary to interview a large number of flight attendants and pilots.
However, some questions were also about personal impressions of the respondents and therefore more than one person has been interviewed. It was chosen to interview three and not two flight attendants and pilots, in order to prevent that the answer to a question is the opposite of the corresponding answer of the other respondent. By interviewing three people of each group, contradictory answers could be prevented.

The interviews contained, for example, questions about the daily tasks of the staff and about aspects they are struggling with or they would like to be improved. The detailed questions and corresponding answers of the interviews with the pilots can be found in *appendix A* on page 100 and the detailed questions and corresponding answers of the interviews with the flight attendants can be found in *appendix B* on page 105.

To identify the problems of the passengers, a survey was conducted with 100 potential passengers. The number of respondents was limited to 100 since the platform *survio.com* was used to conduct the survey and with a free account one is only allowed to obtain 100 answers. The questions and answers of the passenger questionnaire can be found in *appendix C* on page 114.

1.3.1 SUMMARY INTERVIEWS PILOTS

Procedures before the flight

Before a pilot gets on board, he first prepares the flight together with the copilot. The preparation includes for example checking the weather, looking at the status of the aircraft, calculating the needed mileage, and determining the route. Afterwards, the pilots have a briefing with the cabin crew about the upcoming flight.

Then the staff goes on board. One of the pilots is in the cockpit and prepares the aircraft for the flight; this means that he programs the navigation of the computer by inserting parameters into the system. The other pilot is responsible for the security checks. He walks around the aircraft and checks whether everything is working. Additionally, the system continuously checks if everything is working and gives alerts when there might be an error. The pilot then needs to verify the error and when something is broken he resets the corresponding system. If that does not help, an engineer needs to repair the broken system or part.

Procedures during the flight

When everything is working and the machine is programmed, the flight starts. The take-off and the landing of the aircraft are done manually, but the rest of the time the machine is set on autopilot which means that the pilot does not fly the aircraft himself but he manages the flight by controlling the autopilot.

During the flight the pilots are accompanied by air controllers and every half an hour fuel checks are done to check whether it is in accordance with the calculations made beforehand. Furthermore, a so called flight log is filled in for documentation.

Working and resting times

The working time of a pilot depends on the amount of flights per day and the daytime. Usually, a pilot works for a maximum of 13 hours including the ground time. After that time, a pilot has to rest. Only during a very long flight there might be three pilots on board, so that one can rest while being on the aircraft. Then, a pilot can also sleep on board if he wants to. The interviewed pilots only fly within Europe, so they do not sleep during a flight.

Positive and negative aspects about the work as pilot

The interviewed pilots told about the positive as well as the negative aspects of their work. In general, pilots seem to like that they travel a lot and that they receive a good salary. One pilot also mentioned that he finds his work interesting and challenging and another pilot said that pilots cannot work at home, so when one has finished his shift, he has no work left that needs to be finished at home.
The negative aspects include the working times, the fact that a pilot is often away from home, the high amount of money one has to spend to become a pilot, the high working pressure, and that one might get bored during the flight.

Possible improvements

Also some problems occur when working as pilot. The ground handling sometimes does not work that good, so that it might not be clear if

everyone has already boarded and the aircraft is ready to take off. Sometimes there is a language barrier with the ground staff which makes communicating difficult. Furthermore, the ground staff might make mistakes like, for instance, drive the stairs against the aircraft.

Another aspect which could be improved is that when switching on the system of the aircraft the subsystems are not automatically switched on, but every subsystem needs to be switched on separately. One of the interviewed pilots said that autonomous flying could improve the work of the pilot.
That means that the air controllers could send commands to the aircraft and then only one pilot would need to be on board. The pilots also mentioned during the interviews that the working and resting times should be improved, since now pilots have to work at a maximum.

Sometimes there also occur a few communication problems between the cockpit crew and the cabin crew. Since the door between the cockpit and the cabin needs to be closed as much as possible, the pilots and the flight attendants communicate with each other by using a telephone. This way, there might occur misunderstandings, especially because the pilots are quite factual and straightforward and the flight attendants are more focused on the service. To prevent misunderstandings between the crews, there frequently are communication workshops for both of them.

1.3.2 SUMMARY INTERVIEWS FLIGHT ATTENDANTS

Procedures before the flight

Before getting on board the cabin crew meets with the pilots for the briefing about the upcoming flight. During the briefing the positions and tasks within the aircraft cabin are distributed. Furthermore, the pilot asks if everyone is fit enough to fly and if there have been medical incidents earlier. Then he tells the predicted time of arrival and the total time of the flight.

Afterwards, the staff gets on board and the flight attendants conduct the security checks based on checklists. The security checks consist of checking if everything is where it should be, for instance, if every seat has the required security equipment. Also, the bins, the toilets, and a sample of life vests are checked for hidden objects. Next, the passengers get on board and the flight attendants start with the service tasks.

Procedures during the flight

The following procedure depends on the length of the flight; in this summary only the procedure during a long distance flight is described. The description of the procedure of a short distance flight can be found in *appendix B* on page 105.

During a long-distance flight, the first task is to distribute drinks. Also, the ovens for the meals are heated. The meals are prepared beforehand and only need to be warmed. For first class passengers sometimes basic food, like an egg, is cooked in the galley. When a passenger has

special requests for his meals, he can order a so called *special meal* beforehand. On the package of the meal is noted what kind of meal it is, for example, lactose free, and which passenger ordered the meal as well as the corresponding seat number.

When the meals are ready they are distributed to the guests and as soon as the guests are ready with eating, everything is collected and brought to the galley. Afterwards the on-board sales are made.

Next, the purser or purserette, the senior flight attendant, determines the guard and pause times for everyone. A part of the crew has the first guarding shift and the other part can rest. During the break, the flight attendants are allowed to sleep. The duration of the break depends on the length of the flight. Usually one has a maximum of three hours to sleep. Flight attendants sleep in a small cabin in the cabin rest.

Two of the interviewed flight attendants said that they can sleep well on an aircraft and that they did not have to get used to it. One of them said that she was struggling to fall asleep in the beginning but that it has gotten better. She struggled with falling asleep because of the droning of the aircraft and other people are moving the whole time.

During the guard shift, the flight attendants prepare trolleys with drinks and check every half an hour if anyone needs something. Moreover, the toilets are checked; they are not cleaned but it is checked, for instance, if someone smokes in there. After the first half of the guarding time, the shifts are switched and the part of the crew who had the guarding shift can rest and the other way around. The flight attendants who have the second guard shift have to prepare the meals at the end of their shift.

After the guard time, warm towels (saunas) are handed out which should help the passengers to get awake and fresh. Next, the meals and drinks are handed out and when the guests are finished, everything is collected again and brought to the galley.

Procedures after the flight

Then, the aircraft lands and the passengers get out of the aircraft. The flight attendants check whether no one has forgotten anything and whether everyone left the aircraft.

Positive and negative aspects about the work as a flight attendant

The interviewed flight attendants also told about some positive and negative aspects about their work. Generally, it is seen as an advantage that flight attendants travel a lot and that they constantly meet new people. Flight attendants always work in another team constellation, this might be an advantage but it might also be a disadvantage since when you get along with another person very well you are unlikely to work with that person again. And there is also a chance that you have to work with people that you do not get along with very well. Nightlights and jet lags are also mentioned to be exhausting and one flight attendant said that because of the dry air in the aircraft, illnesses can get significantly worse.

1.3 TARGET GROUP RESEARCH

Possible improvements

In the aircraft a few problems might occur. Often there are technical outages and it takes a lot of time until it is repaired. Moreover, in the business class one flight attendant is responsible for 16 guests; according to the interviewed flight attendants this is very stressful. One flight attendant also mentioned that the teams are that big that one purser cannot manage everything and that this should be improved.
Furthermore, the layovers should be longer so that there is more time to rest. Yet another aspect that could be improved is that emergency cases should be treated more during the briefing with the pilots and the rest of the crew.

Generally, there are not a lot of activities flight attendants are struggling with. In the beginning, they had to get used to uncommon situations like, for example, when a passenger fainted or someone brought a dangerous substance on board. There are also a few workshops that prepare the flight attendants for such situations.

One flight attendant said that *seniority* often is a problem. *Seniors* are those flight attendants who already work for the airline for a long time. Based on their *seniority*, they have a lot of freedom of choice. They can for example pick their favorite position and task. So some flight attendants rest on their *seniority* and refuse to work on a position other than their favorite one or to do some tasks they do not like.

Another aspect is that flight attendants are not allowed to lift the bags of the passengers. Some flight attendants do this anyway, since they do not like refusing to help. Hence, there are sometimes discussions about that within the crew. Moreover, flight attendants usually try to avoid arguments and therefore they accept stress and rude behavior. In the long run it is not healthy to always be friendly even when one is in a bad mood. In case that a major difficulty occurs, the purser has to deal with it and needs to settle the dispute.

Another aspect mentioned by one of the interviewed flight attendants is that one needs to turn over two knobs to lock the trolleys for storing them; the same holds for the box of the trolleys. When a knob is forgotten, the trolley is not locked properly and can still move.

Also, it has been mentioned that it can be inconvenient to count how many normal and *special* meals are on board and where the passenger sits who ordered a *special meal*.

Handling of jet lags

Furthermore, it might happen that someone is not concentrated because of tiredness or a jet lag. There are no uniform strategies to avoid or to quickly overcome a jet lag.
Some flight attendants keep their normal time rhythm to avoid a jet lag, and a few take sleeping pills to get into the new time rhythm. Others take a short nap during the day to overcome the tiredness and some flight attendants have created exact sleeping patterns they have to stick to in order to avoid a jet lag.

Fraction of passengers with a fear of flying

During the interviews the flight attendants told that they often have to deal with passengers who have a fear of flying.
One flight attendant said that she would guess that there are a few passengers with a fear of flying on every fifth flight. The second flight attendant said that during a workshop she was

told that about 50% to 80% of the passengers are afraid of flying and that one can notice this fear at about 10% of the passengers.
The last flight attendant who has been interviewed said that there is always someone on board who has a fear of flying. About every tenth flight there is someone on board who has heavy reactions as a result of his fear of flying.

Heavy reactions are for example that the passenger starts to cry, that he throws up, that he faints or that he has a panic attack. When a flight attendant notices that a guest is afraid of flying, he or she tries to settle him by calmly talking to him. In most cases this helps a little.

Frequency of medical emergencies

During the interviews, the flight attendants talked about medical emergencies on board. According to them, there is at least one person who faints on every flight.

Another incident that occurs quite frequently is that a passenger throws up. In such cases flight attendants are schooled how to help the concerned passenger, since they have to do a first aid workshop to refresh their skills every year. Really bad incidents do not occur that often.

In case of emergencies in which the flight attendants cannot help, they ask if one of the passengers is a doctor and if he could help.
Normally, there is at least one doctor on board who can help in such a case. If there is no one on board, it is possible to call an emergency hotline. Then a doctor tells the flight attendants what exactly they have to do and which route the pilot can take to get to the nearest hospital.

Occurrence of communication problems

A main aspect of the work as flight attendant is communication. According to the interviewed flight attendants the communication between the passengers and the cabin crew is generally good. Sometimes there are some passengers who complain a lot and they might even get angry or threatening. Flight attendants frequently have workshops to be able to handle such a situation. They learn for example how to defend themselves even against very tall or heavy persons and also how to bond them.

Usually, also the communication with the pilot is good. Once in a while there are some misunderstandings because both crews are focused and trained on different aspects. The cockpit crew is very straightforward and factual while the cabin crew is focused on the service. In addition, there sometimes are some disagreements between the cockpit crew and the cabin crew concerning the procedures. To prevent misunderstandings and disagreements, there are communication rules and frequent workshops for both crews.

Also between the flight attendants there usually do not occur any communication problems, since they are trained to be able to solve conflicts and to get along with nearly everyone. Anyway, every now and then there are crew members who do not get along; then the purser is responsible for settling the dispute. Also in some team constellations the team members do not communicate enough and then it might happen that someone makes a mistake or that misunderstandings occur.

1.3 TARGET GROUP RESEARCH

1.3.3 SUMMARY SURVEY

100 people have filled in the questionnaire *Passengers' experiences* that can be found in *appendix C*. Nearly every age between 12 and 64 years is represented even though most of them are between 21 and 30 years old. The second largest age group consists of 12 to 20 year olds. About 59.2% of the respondents are female and about 40.8% are male. Out of all respondents, 96% said that they have flown before and 39.6% of them also fly on a regular basis. 37.5% of the people who have never flown before have not done it yet because of their fear of flying.

Nervousness about flying

Most people, namely 53% do not feel nervous about flying, but a great amount, 27%, does sometimes feel nervous about flying and also 20% always feel nervous about flying. About half of the people who are always or sometimes nervous about flying consider their nervousness as fear of flying.

The two main reasons for their fear are that they are frightened of having an accident and that they are not in charge of control of the situation. They usually handle their fear by trying to avoid thinking about having an accident, remind themselves of the unlikeliness of having an accident, and by distracting themselves by doing something like listening to music or reading.

Positive and negative aspects about flying

Most of the respondents like about flying that it is a fast way of travelling. A lot also said that they like the view. The main aspects which people usually do not like are that there is not enough space in an aircraft cabin, the waiting time before the flight, and the fear of having an accident.

The most interesting aspects for this assignment could be that people do not like flying because they are afraid to have an accident, that they feel the turbulences of the machine and do not know what is going on, that it is very noisy in an aircraft cabin, and that people do not like that they are not in charge of control.

Communication between staff and passengers

Additionally, questions were asked about the communication between the flight attendants and the passengers as well as about the communication between the pilot and the passengers. Nearly everyone is pleased with the communication between the staff and the passengers. Reasons for being not pleased are that there barely is any communication, that one does not get enough information and updates on the flight and that the pilot usually does not introduce himself.

Possible improvements

The respondents also listed a few aspects which could be improved. While the two aspects which have been mentioned the most are that the seats should be more comfortable and there should be better offers on entertainment, a lot of people also mentioned that there should be more information on the flight. This could be in the form of explanations from the pilot about what he is doing next or where the aircraft currently

is, but also in the form of an explanation about the physics of the aircraft.

Sleeping behavior on an aircraft

About half of the respondents cannot sleep well on an aircraft. Most are struggling with falling asleep as well as with staying asleep. The reasons for this are for example that the passengers cannot sit comfortably, that the air quality is bad and also the surrounding noises and the movements of the aircraft.

Feeling of safety

77.1% of the respondents feel safe on an aircraft because they trust the technology as well as the staff and because they are aware that flying is statistically the safest way to travel. The respondents who do not feel safe mentioned a few reasons for this. The main reasons are that they are not in charge of control and that they think that one is likely to die if there would be an accident.

1.3.4 CONCLUSION OF THE TARGET GROUP RESEARCH

To conclude, pilots do not seem to be a suited target group for this bachelor assignment. In the cockpit already are a lot of computers so that adding a new one would probably make it more confusing. Furthermore, it can be interpreted that pilots do not have struggles while flying the aircraft that might be solved by a wearable. When being asked with which tasks the pilots are struggling, they only mentioned problems that do not occur while being on the aircraft. Moreover, the aircraft is set on autopilot during the flight, so pilots only need to keep an eye on the parameters which might change during the flight like, for example, the weather.

Flight attendants also claim to only have a few minor problems during a flight. However, they might overlook aspects that could be improved. Since they are used to perform their tasks manually they might not see that some tasks could be performed more efficiently. Therefore, during the next phase, it has been critically searched for potentials to create a wearable for the cabin crew based on wearables that already have been tested on an aircraft, the scope of duties of a flight attendant as well as problems that sometimes occur, both obtained from the interviews.

Additionally, one aspect that had been mentioned by one of the interviewed flight attendants is that illnesses are likely to get significantly worse in an aircraft cabin due to the bad air quality. In the next phase, research has been done on possibilities to protect other people on board from getting infected. The starting point of the research was electronic fibers, mentioned in the *Market research* on page 17. These electronic fibers can detect disease and radiation, control the release of pesticides, kill bacteria, and capture hazardous gases.
Other aspects, on which research has been done during the next phase of the assignment, are how to help people to overcome their nervousness about flying, and how to help people to fall and to stay asleep.

CONCEPT PHASE

2.1 INTRODUCTION CONCEPT PHASE

Based on the market and target group research of the previous chapter, four new research questions arose which are answered in this chapter: 'How can the spread of illnesses on an aircraft be prevented?', 'How can a passenger overcome his nervousness about flying?', 'How can sleeping behavior on an aircraft be improved?', and 'What are potential functionalities for a device for the cabin crew?'.

Each of the questions mentioned above was the basis for a concept idea. Hence, for the first concept idea, a closer look on the background of the spread of illnesses and on antibacterial materials was taken.
Before this concept idea was worked out more detailed, it has been dropped.

For the second concept idea, background information on fear of flying and treatment methods were looked up and it was brainstormed for solutions.

The elaboration of the third idea consists of research on methods to improve sleep quality and existing products which help to improve sleep quality.

The last concept idea was a little less concrete in the beginning of this phase, so for this idea it was necessary to examine potentials for functionalities based on wearables that already have been tested on an aircraft, the scope of duties of a flight attendant as well as problems that sometimes occur during their work.

After the ideas were elaborated, a concept idea was chosen and the questions 'Which functionalities are valuable for a wearable to have?', 'How could the functionalities be realized?', and 'Which device is suited to perform the functionalities?' were answered.

2.2 CONCEPT IDEA 1:
DEVICE FOR PREVENTION OF SPREAD OF ILLNESSES

Air travel can influence the global spread of infectious disease. People can get infected due to various factors and also infected disease vectors, such as malaria-infected mosquitoes, can be transported on an aircraft by accident. The greatest concern might be that a person with a contagious illness can travel around the world *(Pavia, 2007)*.

In an aircraft cabin there are particularly good conditions for getting infected. Several factors contribute to the spread of viruses. On the one hand, there are a lot of people in a narrow space so that the likelihood that one or more of the passengers are infected is very high. In addition, there is a very low humidity in an aircraft cabin. Therefore, the mucous membranes easily dry out and viruses can settle more easily. The last factor that leads to an increased chance to get infected in an aircraft cabin is the ventilator. The ventilator distributes bacteria within the cabin and therefore increases the distribution of infections *(Medipresse,n.d.)*.

Antimicrobial imidazolium oligomers

Researchers 'have developed a synthetic molecule capable of killing bacteria such as E.coli in seconds' *(Nanowerk, 2016)*. The material has been created by using positively-charged molecules linked together in a chain to attract negatively-charged bacteria cells.
Due to its structure the bacteria are destroyed. Each chain has a 'tail' at its end which acts as a drill and kills bacteria. For instance, the material can kill 99.7% of E.coli bacteria within 30 seconds. The material has not yet been applied as a textile, but it is still in development and might come on the market in a variety of structures *(Nanowerk, 2016)*.

Antibacterial fabric

Silver has a great ability to kill bacteria. These qualities are the basis for an antibacterial fabric developed by researchers of Australia's *RMIT University* in cooperation with scientists from the *CSIRO*. The material can destroy E. coli and other bacteria within 10 minutes of contact.
Embedded nanowires which are loaded with silver-TCNQ (tetracyanoquinodimethane) are embedded into a textile to create the antibacterial fabric. When coated in a silver solution, the nanowires release silver-ions which kill of bacteria. The fabric can be built into most materials and even after five days the material still releases silver-ions. These materials may be great to be applied in hospitals to curtail hospital-acquired infections (Lavars, 2014).

Bacteria-killing textiles

Researchers at the *University Politècnica de Catalunya BarcelonaTech* (UPC) in Spain have developed bacteria-killing textiles. These textiles could be used to prevent the spread of infections acquired within hospitals.
To embed antimicrobial nanoparticles within textiles, adhesive enzymes are used. The enzymes help securing antibacterial agents to the fabrics, when applied under ultrasonic radiation. These agents still remain after 70 laundry cycles *(Toor, 2012)*.

2.3 CONCEPT IDEA 2:
DEVICE TO OVERCOME NERVOUSNESS ABOUT FLYING

The results of the conducted survey showed that many people feel nervous about flying or even have a fear of flying. To help them to overcome their nervousness about flying a wearable might be useful. In order to find out if a wearable could help and what the functions of such a wearable should be, research had been done on what fear of flying exactly is, what the causes and symptoms are, how many people have a fear of flying or feel nervous about flying, and how fear of flying is treated. Also, to brainstorm for solutions, a mind map has been made which can be found in *appendix D* on page 120.

What is fear of flying?

People who have a fear of flying are afraid of being on an airplane, or any other flying vehicle, while in flight. Fear of flying is also referred to as flying phobia, flight phobia, aviophobia or aerophobia. This fear may be a distinct phobia in itself but it can also be a combination of disorders like claustrophobia and acrophobia (fear of heights). Fear of flying is not a disease but it is more like a symptom caused by different aspects depending on the individual *(Wikipedia, 2017)*.

How many people have a fear of flying?

There are a lot of different numbers about how many people feel nervous about flying or who are actually afraid to fly. For instance, the charity *Anxiety UK* mentions in an article that it is believed that fear of flying affects 10% of the population, but that studies suggest that the proportion is much higher *(Anxiety UK, 2015)*. According to some other estimates, as many as 25% of all Americans suffer some nervousness about flying *(Seaney, 2013)*, and according to the *National Institutes of Mental Health*, intense fear of flying affects an estimated 6.5 percent of Americans, *(DePillis, 2014)* which are still more than 20 million people *(Seaney, 2013)*. Another source says that as many as 20% to 30% of people are apprehensive about flying and between 2% and 10% of people have a flying phobia *(Ponton, 2016)*. Yet another number that can be found is that 40% of travelers have a fear of flying *(Zacchia, 2014)*.

The result of the survey *Passengers' experiences*, which has been conducted for this assignment, is that 20% of the people feel nervous about flying and that 27% do sometimes feel nervous about flying. 51% of the people who always or sometimes feel nervous about flying consider this nervousness as a fear of flying. This means that about 24% of the respondents claim to have a fear of flying. Hence, even if there are no consistent percentages about the amount of people who are afraid to fly, it can be claimed that a great part of the population does actually feel nervous about flying.

What are the causes and symptoms of a fear of flying?

There are no uniform causes and symptoms for fear of flying. Every individual experiences different symptoms such as panic attacks, headache, stomachache, muscle tension, rapid heartbeat, sweating, shortness of breath, irritability, and trouble concentrating *(Bailey, n.d.)*.
Some people, for instance, are afraid that they will lose control of their emotions during a flight and that they embarrass themselves in front of fellow passengers. People who have this kind of fear may have concerns about having a panic attack, becoming hysterical or losing control of bodily functions.
Some others associate their fear with external factors like turbulences, bad weather or technical problems *(Anxiety UK, 2015)*. Furthermore,

flying is very stressful for many people due to the long waiting times and the extensive security procedures. On top of this, they might have the fear that something may go wrong with the plane while in the air. For people with anxiety a number of aspects can be triggers to cause fear of flying. Such triggers can be:
fear of heights, fear of being in enclosed or crowded areas, fear of being over water or social anxiety *(Bailey, n.d.)*.

Moreover, many people are triggered by the media. Aircraft incidents are often represented as very dramatic so that people intend to imagine that all aircraft crashes are catastrophic events. They think that when an aircraft crashes everyone on board dies; but in reality 95.7% of people who are involved in a crash survive.

Researchers believe that fear of flying is a learned fear, thus that a fear of flying develops over time. It can be the result of negative experiences with flying.
When someone, for instance, experiences turbulence, loud noises, and also pain due to pressure changes during a flight, it is possible that an anxiety is triggered and that he also associates other aspects of flying with that anxiety.

Next to the factors listed before, there are also a range of other factors that can act as stimuli. Such factors might be stress, personality factors such as someone who does not like not to be in charge of control, misinformation about the danger of flying and a biological predisposition *(Ponton, 2016)*. Also, some people do not develop a fear of flying until they get married or have a child. Then, people feel like their life is more valuable and they are more afraid to fly because their family depends on them *(Zacchia, 2014)*.

How is fear of flying treated?

According to Dr. Martin N. Seif, there are a few steps that a person with a flight phobia can follow to overcome a fear of flying. The first step is to figure out what the cause for one's fear of flying is and to identify the triggers for the anxiety. When one knows the causes, it is easier to control them.

The next step is to get informed about the facts so that it becomes easier to manage the anxiety. One should also try to separate fear from actual danger. To do so, the concerned person should constantly tell himself that he is safe even when he experiences anxiety. Additionally, one should learn about airplanes. When one knows how an aircraft is designed to handle turbulences, one knows that it is safe and managing the anxiety gets easier. Seif also recommends letting the other fliers know what frightens the concerned person and how they could help to cope with the anxiety *(ADAA, n.d.)*.

During a flight it can also be helpful to take a look at the flight attendants when feeling uncomfortable due to turbulences. When there is nothing wrong, the flight attendants will act just as normal and the concerned passenger knows that such turbulences are not uncommon.
Something that might also help passengers with a flight phobia is to fly in the business class. Since a lot of people are fearful of flying, there is a great chance that the aircraft cabin is filled with many other people who have a fear of flying and when someone panics, the rest will also become uneasy. In the business class, the atmosphere is more private and calm and this might help a person with a flight phobia to also stay calm *(Zacchia, 2014)*.
Furthermore, people can be treated professionally by participating in a workshop or by

2.3 CONCEPT IDEA 2:
DEVICE TO OVERCOME NERVOUSNESS ABOUT FLYING

having a therapy. Workshops to overcome fear of flying are offered by a lot of airlines. *Virgin Atlantic* offers, for example, a one day seminar. In the seminar the participants learn how planes work, they also have the chance to ask questions to pilots, and they have a therapy session *(Seaney, 2013)*. In this session, the participants learn how fear develops, how to recognize one's current fear patterns and techniques, tools, and ideas from cognitive-behavior therapy, neuro linguistic programming, thought field therapy and mindfulness. This shall help to interrupt the old fear patterns and re-train the participants to think and feel differently about flying *(Virgin Atlantic, n.d)*.

Some of the topics that are treated during the seminar are (*Virgin Atlantic, n.d.)*:

- How an aircraft flies,
- How such a heavy thing stays up in the air,
- Why turbulence is totally safe,
- What the pilots are trained in,
- What the pilots would do if there was an engine failure,
- What all the noises are on board,
- Stages of the flight with full explanation of noises and movement,
- What are the airlines doing about terrorism,
- Why nothing is ever left to chance.

At the end of the seminar the participants are going on a short flight. During this flight, one of the pilots 'will give a full commentary of what is happening at every stage of the flight. Every noise and every movement will be fully explained' *(Virgin Atlantic, n.d.)*. Due to the knowledge the participants gain understanding and they feel that they have control (*Virgin Atlantic, n.d.)*.
The airline claims a success rate of 98% *(Seaney, 2013)*. Also the airline *British Airways* has an impressive success rate of 98.6% with courses given to more than 45,000 over the last 25 years *(Zacchia, 2014)*.
The courses of *British Airways* are similar to the ones of *Virgin Atlantic*. First, pilots give a presentation. Since 'there is strong evidence to suggest that one of the main causes of fear of flying is simple lack of knowledge about how an aircraft flies and operates. So, the pilots give a detailed talk explaining the technical side of aviation especially concentrating on air turbulence, flight safety and much more' (*British Airways, n.d.)*.
These programs offered by airlines are based on Albert Bandura's concept of belief in self-efficacy. According to Bandura 'belief in one's capability to organize and execute the courses of action is required to manage prospective situations. Efficacy beliefs influence how people think, feel, motivate themselves, and act. Expectations concerning mastery or efficacy are assumed to determine choice of actions, the effort one expends, the persistence in the face of adversity as well as one's emotional or affective experiences' *(1977, pp. 2-3)*. It is possible to improve self- efficacy through four channels. The first one is formal provision of information. The second channel implies the development of skills to control inner states; examples for some skills are controlled breathing, muscle relaxation, the negative thoughts 'stop' technique, and distraction from negative thoughts. The third

channel is learning by example and the last channel is active attainment, thus active copying with specific tasks *(Van Gerwen et al., 2001)*.
As it has been mentioned, there are various methods to treat fear of flying. Nevertheless, mainly cognitive-behavioral therapy (CBT) is used. 'This involves exposure therapy, cognitive restructuring and relaxation techniques. A professional can extinguish a phobia through either graded exposure (desensitization) or intensive exposure (flooding)' *(Ponton, 2016)*.

CBT is a talking therapy that can help to manage problems by changing the way of thinking *(NHS, 2016)*. It is mainly used to treat anxiety and depression. The basic thought of CBT is that 'thoughts, feelings, physical sensations and actions are interconnected, and that negative thoughts and feelings can trap [one] in a vicious cycle' *(NHS, 2016)*.

The aim of the therapy is to help the concerned person dealing with overwhelming problems. By breaking these problems down into smaller parts and changing the negative patterns, one can deal with the problems in a more positive manner *(NHS, 2016)*.

So, as mentioned before, for behavioral treatment for fear of flying two methods can be used: intensive exposure and desensitization. When intensive exposure is used, the patient is exposed to the situation that produces anxiety and avoidance behavior. It 'may be conducted by having patients imagine they are in the feared situation or by having patients placed in the actual feared situation' *(Kormos, 2003)*.

While being exposed, the anxiety of the patient is increased until a patient's physiological measurements such as blood pressure and heart rate, and psychological measurements peak and then decrease to a baseline measurement. Returning to the baseline measurements is called *habituation*. Exposure therapy can also be carried out by imagining a scenario or by using virtual reality (VR). It is reported that a variety of cases of fear of flying have already successfully been treated by using VR *(Ponton, 2016)*. This form of exposure therapy uses virtual reality to make people experience turbulence and harsh weather conditions to confront them with their fears. While some researchers say that this method has had positive results, others say that participants are aware that they are not on an airplane and that they do not need to be afraid *(Zacchia, 2014)*.

When desensitization is used, the patient is gradually exposed to a stimulus while being in a relaxed state. 'The patient is taught skills in muscle relaxation. While in a relaxed state, the patient is presented with the phobic stimulus in graduated time increments' *(Kormos, 2003)*.

In a case study, the treatment of a patient with a fear of flying consisted of three phases. During the first phase the patient should imagine himself sitting on a plane and the therapist guided the patient through a scenario. During these sessions, blood pressure and heart rate were monitored and the patient was frequently asked to describe his level of anxiety from a scale from one to eight, that is, he was asked to describe his SUDS (Subjective Units of Distress Scale).
During the second phase, the patient was exposed to a more realistic situation: the therapist instructed the patient to go to the airport and sit in the waiting area.

During the third phase, the patient was exposed more intense. The patient used imaginal sessions like in the first phase at home on his own and in the meantime he got the task to plan a

2.3 CONCEPT IDEA 2:
DEVICE TO OVERCOME NERVOUSNESS ABOUT FLYING

trip, without informing himself about the type of aircraft and likelihood of mechanical failures. The patient, who had been treated by using these three phases, went on a trip to South America and after returning, he reported that he only felt mild anxiety during his trip *(Kormos, 2003)*.

Another method that may be effective in treating fear of flying is *Eye Movement Desensitization Reprocessing* (EMDR). During an EMDR session, the patient focuses on his anxiety while the therapist moves his fingers in front of the patient's eyes *(Newgent et al., 2006)*, as shown in *figure 2.1*. 'EMDR proponents have invoked a dizzying array of explanations for the apparent effectiveness of the lateral eye movements: distraction, relaxation, synchronization of the brain's two hemispheres, and simulation of the eye movements of rapid eye movement (REM) sleep have all emerged as candidates' *(Arkowitz et al., 2012)*.

According to the case study *Single Session Treatment of Nontraumatic Fear of Flying with Eye Movement Desensitization Reprocessing*, a woman had a panic attack during a flight and was then treated using EMDR while being on the aircraft. EMDR is usually less effective than cognitive-behavioral therapy since exposure is missing in EMDR *(Arkowitz et al., 2012)*. Due to the fact that the patient was exposed to her feared situation, EMDR seemed to be very effective *(Newgent et al., 2006)*.

Figure 2.1: Patient is treated with EMDR therapy

2.3.1 POTENTIAL FUNCTIONALITIES FOR A DEVICE TO OVERCOME NERVOUSNESS ABOUT FLYING

Requirements concerning the user's emotions:

- The device must help people to reduce their nervousness about flying.
- The device must decrease the fear of having an accident.
- The device must ensure that the user feels more in charge of control of the situation.

Functions:

- The device must help to distract the user from thinking too much about their nervousness.
- The device must improve the communication between the staff and the passengers.
- The device must help the user to find out what frightens them about flying.

Requirements on providing of information:

- The device must provide information on the statistics of aircraft accidents.
- The device must provide information on the surrounding noises and the movements of the aircraft.
- The device must provide information and updates on the current flight.
- The device must provide information on the physics of the aircraft.
- The device must provide information on the topic how fear develops.
- The device must provide information on how the user can develop skills to control inner states.

2.4 CONCEPT IDEA 3:
DEVICE FOR IMPROVING SLEEPING BEHAVIOR

Many people struggle with sleeping on an aircraft. For instance, 53.1% of the respondents of the survey *Passengers' experiences* said that they could not sleep well on an aircraft. About half of them said that the cause for their sleeping problems on an aircraft are the surrounding noises and most also said that they could not sleep because it is not comfortable enough. To improve the passengers' traveling experiences, research has been done on how sleeping behavior of air travelers could be improved. Of course, there are a lot of tips for travelers that cannot be integrated into a wearable, such as avoiding caffeine and alcohol. Hence, the research only applies to problems that could be solved by a product. Additionally for brainstorming for solutions, a mind map has been made which can be found in *appendix D* on page 120.

2.4.1 PRODUCT INDEPENDENT SOLUTIONS

General solutions

For many passengers it is a problem that it often is cold on an aircraft. When it would be warmer in the cabin or when the passengers would use a blanket, they might sleep better.
Also, passengers who like to lean their head against a wall might want to sit in a window seat. To make sleeping on a plane more comfortable for every seat location, a pillow should be used. Additionally, the lights and sounds on an aircraft can be disturbing and make falling asleep more difficult. Therefore, passengers could use an eye mask and headphones that shut out the surrounding noises *(Van der Haar, 2016)*.

Music-assisted relaxation

The review paper *Music-assisted relaxation to improve sleep quality*, compares five different studies on the topic whether sleep quality can be improved by music-assisted relaxation (MAR).
According to clinical studies, music could counteract psychological pre-sleep arousal and in this way the preconditions for sleep could be improved. Additionally, it has been shown that music is capable to influence emotions in a positive way. Music also decreases the level of anxiety.

The studies of Harmat et al., Kullich et al., and Lai and Good had the best results. For the study of Harmat et al. the participants listened to standardized classical music for 45 minutes a day at bedtime for a duration of three weeks. There were no additional relaxation measures and the outcome was a statistically significant improvement of total sleep quality.

The same outcome had the study of Kullich et al.as well as the study of Lai and Good. For the former study the participants listened to standardized music at least once a day at no specified time for a duration of three weeks. Additionally, the participants received a booklet with relaxation text. For the latter study the participants listened to self-selected sedative music for 45 minutes a day at bedtime for a duration of three weeks and they also got additional relaxation instructions.

To sum up, the results of the five studies show that MAR is an effective aid for improving sleep quality. Moreover, it can be assumed that addi-

tional relaxation-improving measures such as oral or written instructions do not contribute a lot to the improvement of sleep quality *(De Niet et al., 2009)*.

MAR vs. Audiobooks

The study of Harmat et al. did not only study the improvement of sleep quality through music but also through audiobooks. While listening to sedative classical music had a positive effect on sleep quality and depressive symptoms, listening to audiobooks did not have statistically significant effects on sleep quality and depressive symptoms *(Harmat et al., 2007)*.

2.4.2 PRODUCTS TO IMPROVE SLEEP QUALITY

Based on the research about the improvement of sleep quality, a small market research has been done on products that help to improve the user's sleep quality. One device that helps to improve the sleeping behavior are the *Kokoon* headphones mentioned in *Market research* on page 17. Others that might be interesting for this assignment are listed below. Two of the products are smart sleep masks and the last product is a smart headband.

LucidCatcher smart headband

LucidCather (figure 2.2) is a smart headband for improving the sleep quality by providing lucid dreams to people. By using the wearable device, the wearer can reach a state of consciousness in a dream where he is actually capable to modify his dream at any time. Dreams are seen during the Rapid Eye Movement phase (REM). The *LucidCatcher* detects the REM of the wearer and syncs the wearer's brain wave to a conscious wave by using electrodes embedded in the headband. In this way, the logical brain is brought back into service and the user realizes that he is dreaming and can therefore modify his dream *(Luciding, n.d.)*

Figure 2.2: LucidCatcher

2.4 CONCEPT IDEA 3:
DEVICE FOR IMPROVING SLEEPING BEHAVIOR

Lulleep smart sleep mask

Lulleep (figure 2.3) is a smart eye mask that is designed to improve the sleep quality of the user. It helps the user to fall asleep by playing sedative music such as natural sounds. The device constantly measures the wearer's brain activity and when he starts falling asleep, the music automatically turns off. The measured brain activity is monitored on an app diary and can be reviewed at any time. The smart eye mask also wakes the user up by using LED lights at an optimized timing *(FraSen, 2017)*.

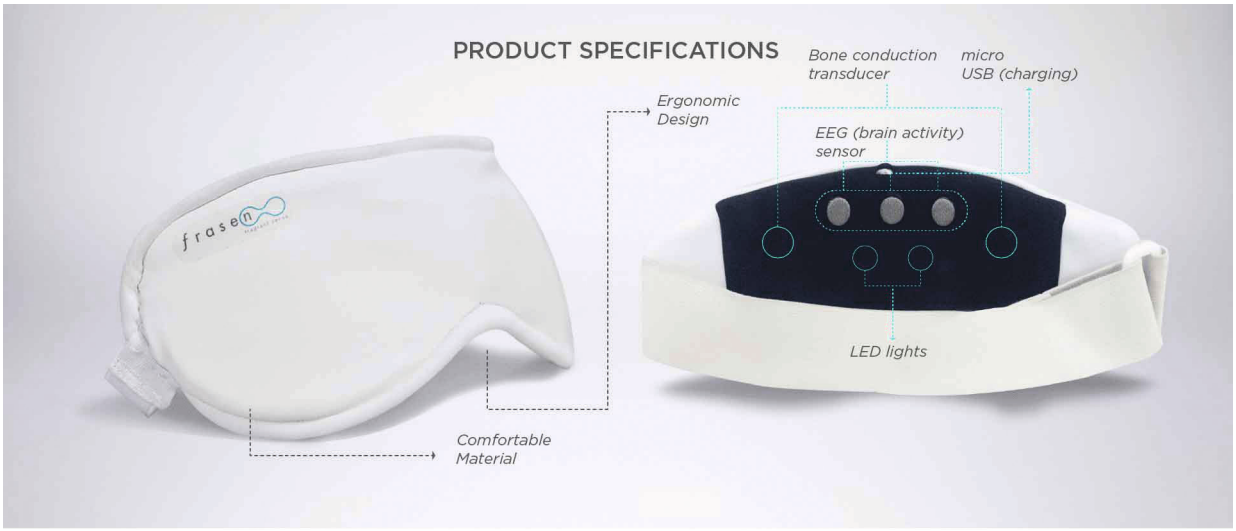

Figure 2.3: Lulleep smart sleep mask

Neuroon smart sleep mask

Neuroon (figure 2.4) is another smart sleep mask for improving the sleep quality. It comes with a companion mobile app, so that the mask can be controlled by using the application. There are six features that can be used: *Sleep Analytics, Jet Lag Blocker, Personal Pause, Biorhythm Adjuster, Neuroon Sunrise and Light Boost (Inteliclinic, 2017)*.

1. **Sleep analytics**
   During sleep, the wearable device measures the user's biological parameters such as brain waves, pulse, body temperature, eye movement and body movement. The *sleep analytics* function gives a detailed report on the quality of the sleep *(Inteliclinic, 2017)*.

2. **Jet Lag Blocker**
   Neuroon helps the user to prevent a jet lag by letting him know how to adjust the body clock to the time zone of the destination. The travel destination is set in the mobile app and then the mask fine-tunes an appropriate light therapy for when the wearer is sleeping. A full jet

lag therapy takes a few days; hence, the *Jet Lag Blocker* should be used some days in advance *(Inteliclinic, 2017)*.

3. **Personal Pause**
   With the *Personal Pause* function the user can set one of three different napping programs: *Power Nap, REM Nap* or *Ultimate Nap*. The mask tracks sleep data and recommends the best time to take a nap *(Inteliclinic, 2017)*.

4. **Biorhythm adjuster**
   The *Biorhythm adjuster* helps the user to get back to his biorhythm. The device makes recommendation for a changed schedule in order to adjust the user's sleep cycle. A personalized therapy is created based on the gained data of the sleep analytics. Then, *bright light therapy* (BLT) is used to help the user to fall asleep faster. During sleep, very short and gentle flashes of light are sent onto the eyelids of the wearer for a certain period of time. Through the light flashes, the amount of melatonin hormone is regulated and the body clock is adjusted to a normal rhythm *(Inteliclinic, 2017)*.

5. **Neuroon Sunrise**
   In order to help the user waking up in a natural way, *Neuroon* simulates the light of a slowly breaking dawn. Additionally, the sleep tracker wakes the user at an optimal moment when the sleep phase is at its lightest point. When the user does not wake up, the mask adds gentle vibrations and finally an audio alarm from the mobile phone *(Inteliclinic, 2017)*.

6. **Light Boost**
   The function *Light Boost* helps to regulate the user's melatonin level by using *bright light therapy*, as mentioned before. Not only does BLT help to fall asleep faster, but it also helps to prevent *Season affective disorder* (SAD). SAD is a mood disorder that most often occurs in the winter and leads to depressive symptoms and BLT can treat this disorder effectively as well as depression *(Inteliclinic, 2017)*.

Figure 2.4: Neuroon smart sleep mask

2.4 CONCEPT IDEA 3:
DEVICE FOR IMPROVING SLEEPING BEHAVIOR

2.4.3 POTENTIAL FUNCTIONALITIES FOR A DEVICE FOR IMPROVING SLEEPING BEHAVIOR

Requirements on main function:

- The device must help the user to fall asleep.
- The device must help the user to stay asleep.

Functions:

- The device must ensure a more comfortable position during the flight.
- The device must reduce the surrounding noises of the aircraft.
- The device must eliminate light.
- The device must help the user to relax.

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

At first sight, it seems as if there are not many potentials to create a wearable that can be used by the cabin crew during a flight. As the interviewed flight attendants claimed, there are not a lot of problems that occur on board. It has been mentioned before that flight attendants are used to perform their tasks manually and therefore it might be possible that they overlook aspects that could be improved. To find potentials for designing a wearable for the cabin crew the various tasks have been analyzed. Moreover, some airlines have already tested some wearables, so the functionalities of these wearables were an inspiration. During the interviews, the flight attendants also mentioned a few aspects that lead to potentials for a wearable. For brainstorming for solutions, a mind map has been made which can be found in *appendix D* on page 120.

2.5.1 OVERVIEW OF TASKS AND CORRESPONDING POTENTIALS

The scope of duties obtained from the interviews with the flight attendants has been divided into the steps that are necessary to fulfill the corresponding task and the potentials for a product that support the cabin crew to perform it. The task description and the steps of which it contains as well as the potentials are listed in *table 1*.

Table 1: Tasks of the cabin crew and corresponding potentials for a wearable

Description of task	Steps necessary	Potentials
Briefing	1. Discuss upcoming flight 2. Distribution of position 3. Distribution of tasks	• Provide discussed information on device
Security checks	1. Check whether everything is at its place 2. Check sample of life vests for hidden objects 3. Check toilets for hidden objects 4. Check bins for hidden objects	• Glasses: checked areas are highlighted green, unchecked areas red (AR) • Objects that should not be there are highlighted and an alert is set off

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

Description of task	Steps necessary	Potentials
Boarding	1. Greet passengers 2. Help passengers find their seat if necessary 3. Check if luggage is stored 4. Check if passengers fastened seat belt 5. Give security instructions	• Get information on passengers (name, date of birth, fly history, specific diet, language skills, seat number) • Not stored luggage, not fastened seat belts, or open bins are highlighted • Translate security instructions automatically in various languages
Prepare trolleys for drinks	1. Get trolley out of trolley box 2. Put glasses into trolley 3. Put drinks into trolley 4. Put tissues into trolley	• Highlight when trolley is ready to be picked out of box • Highlight when glasses or drinks are not stored properly
Distribution of drinks	1. Ask passengers what they would like to drink 2. Fill glasses with corresponding drinks 3. Hand out drinks to passengers 4. Store trolleys	• Provide information on how many glasses of which drink are needed • Drinks can be prepared in galley and not every passenger needs to be asked what he would like to drink • Alert when a drink is nearly empty • Provide information on where an empty drink can be refilled (another trolley, galley) • Highlight when trolley is not stored properly
Heat meals	1. Count meals and 2. Heat the ovens 3. Put meals into the ovens for 30 minutes 4. Get the meals out of the oven	• Automatic counting of the meals • Inform flight attendants when meals are ready

Description of task	Steps necessary	Potentials
Collect empty glasses	1. Collect the glasses 2. Collect trash 3. Bring glasses and trash to the galley and throw them away	
Prepare trolleys for meals	1. Get trolley out of trolley box 2. Put the meals into the trolley	
Distribution of meals	1. Hand out meals to passengers 2. Store trolleys	• Provide flight attendant with information on who ordered which meal ▷ Flight attendant does not need to remember the seat number of the corresponding passenger; information is augmented when arriving at the right seat • Provide information on where an empty meal can be refilled
Collect dishes	1. Collect the dishes 2. Collect trash 3. Bring dishes and trash to the galley and throw them away	
On-board sales	1. Ask passengers if they would like to buy something 2. Hand out the corresponding orders	• Provide information on how many people would like to buy something and what ▷ Exactly prepare the needed amount of orders • Provide flight attendant with information on who ordered something and what ▷ Flight attendant does not need to ask every passenger if he would like to buy something; information is augmented when arriving at the right seat

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

Description of task	Steps necessary	Potentials
Break	1. Sleep or rest in crew room	
Guarding shift	1. Prepare trolley with water 2. Check every half an hour if someone wants some water 3. Check if everything is fine 4. Prepare trolley for breakfast	• Alert when a passenger would like to drink some water ▷ Flight attendant does not need to walk through the cabin every half an hour
Distribution of saunas	1. Prepare trolleys with saunas 2. Hand out saunas to passengers	
Collect saunas	1. Collect saunas	
Distribution of breakfast	1. Hand out breakfast to passengers 2. Store trolleys	
Collect dishes	1. Collect the dishes 2. Collect trash 3. Bring dishes and trash to the galley and throw them away	
Check cabin	1. Check if everyone got out of the aircraft 2. Check if anyone left something in the cabin	• Highlight forgotten objects (or objects that are somewhere where they should not be)

2.5.2 ARTICLES WITH INFORMATION ON WEARABLE TECHNOLOGY FOR AIRLINE STAFF

In order to get some inspiration on potential functionalities for a wearable used by the cabin crew, research has been done on products that already have been tested.

Virgin Atlantic launches Google Glass and Sony Smartwatch 'wearable tech' trial

In 2014, *Virgin Atlantic* had a six-week trial 'to learn how wearable technology could improve the passenger experience and speed up the check-in process' *(Kollau, 2014)*.

During the trial concierges at the London *Heathrow Clubhouse* lounge got equipped with wearables in an effort to give employees more information on business class passengers arriving at the *Upper Class Wing*. The staff was equipped with either *Google Glass* or a *Sony SmartWatch 2 (figure 2.5)*. The devices were integrated to a purpose-built dispatch app as well as the *Virgin Atlantic* passenger service system. The app managed the task allocation and concierge availability and provided the concierge with passenger information on the smart glasses or watch. The technology helped to identify a customer, see the flight details and preferences, and immediately started the check-in procedure of the passenger. During the escorted process, weather and local events at their destination, including translating any foreign language information, was given to the passenger until he reached the lounge. The personalized service could also store preferences for future trips, and eventually could tell *Virgin Atlantic* staff the passengers' food and drink preferences *(Kollau, 2014)*.

Figure 2.5: Sony SmartWatch 2

Tech-Enabled Flight Attendants Upgrade Customer Service

In 2012, *American Airlines* equipped its flight attendants with mobile tablets for use on board of its planes. Now they are equipped with *Samsung Galaxy Note 3* phablets *(figure 2.6)* which enable them 'to receive corporate email, check in for their shifts, and get real-time access to passenger seat assignments, loyalty program status, special service needs, premium class food and drink choices, connecting gate details and other information' *(Baskas, 2015)*. Moreover, apps which help the flight attendants to serve custo-

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

mers better are provided just like *Google language translator*, and weather.
Additionally, an electronic version of the flight attendants' heavy paper manual is loaded onto the devices so that the flight attendants do not need to carry it anymore.

Since 2013, *Delta Air Lines'* flight attendants have been using smartphones in the cabin. They give real-time feedback to the company on things such as catering discrepancies and missing items on the aircraft. With an additional guest services app, the flight attendants have more information on customers and can interact with them better.

Alaska Airlines' flight attendants have been using mobile apps loaded onto *iPhone 6 Plus* phones since May 2015. They 'allow flight attendants to access information such as the seat locations of unaccompanied minors and the location of elite mileage members entitled to special perks' *(Baskas, 2015)*.

Figure 2.5: Sony SmartWatch 2

Airline staff, passengers, and developers are exploring additional ways in which in-cabin devices can be utilized. *Alaska Airlines*, for instance, has a wish list with more than 40 different items including the need for using the digital devices to list the names of qualified people on a flight who could help out in the event of a medical emergency. 'Another suggested use is having an in-app form that indicates whether an unaccompanied minor or a passenger with a special need has been given a required briefing' *(Baskas, 2015)*.

Chinese low-cost carrier Spring Airlines first to equip cabin crew with Google Glass

In China, *Spring Airlines* has equipped flight attendants with *Google Glass* on a flight from Shanghai to Chengdu. 'Details of the specific functionality provided via the *Google Glass* devices are scarce, other than *Spring Airlines* saying that by wearing *Glass*, *Spring Airlines'* flight attendants can get passenger information more intuitively and for example, the name and seat number of passengers shown on the device's screen, allows flight attendants to serve passengers who want to buy food more accurately and timely' *(Kollau, 2014)*.

2.5.3 POTENTIALS GOTTEN FROM INTERVIEWS WITH FLIGHT ATTENDANTS

- The flight attendant teams are that big that one purser cannot manage everything
  - device could help purser to overview team:
    - provides information on who has which tasks
    - provides information on tasks that need to be carried out and that have been carried out already
    - provides information on where the flight attendants currently are
    - enables flight attendants to communicate with the purser via messages and to alert the purser in case of urgency
- Flight attendants have quite a lot of workshops that prepare the flight attendants for various situations
  - Workshop database: Device could provide the flight attendants with information on the workshops in case they forget how to handle the situation
- If there is an emergency on board, it is possible to call an emergency hotline; then a doctor tells the flight attendants what exactly they have to do and which route the pilot could take to get to the nearest hospital
  - Device could have a camera to monitor the situation to the doctors and the device could also have a database with information on various emergency cases

2.5.4 SUMMARY OF POTENTIALS FOR A WEARABLE FOR THE CABIN CREW

Highlight functions

- During the security checks must be highlighted green if they have been checked and everything is fine and areas that have not been checked must be highlighted red.
- During the security check or when the passengers get off the airplane and it is checked whether someone forgot anything, objects that should not be there must be highlighted and an alert could be set off.
- Not fastened seat belts or open bins must be highlighted.
- It must be highlighted when the trolley is ready to be picked out of the trolley box.
- It must be highlighted when the glasses, drinks or meals are not stored properly.

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

Alert functions

- It must be highlighted when a trolley is not stored properly in the trolley box.
- The device must inform flight attendants when the meals are ready.
- The device must set off an alert when a drink is nearly empty.
- The device must set off an alert when a passenger would like to drink some water during the guarding shift.
  - Flight attendants would not need to walk through the cabin every half an hour

Provision of information

- The device must provide flight attendants with information on the flight, workshops and emergency cases.
- The device must provide information on passengers (name, date of birth, fly history, specific diet, language skills, seat number) for a more personalized service.
- The device must provide information on which passengers could help out in case of an emergency.
- The device must provide information on how many glasses of which drink are needed or during on-board sales how many people order something and what.
  - Drinks/Orders could be prepared in the galley and not every passenger needs to be asked what he would like to drink
- The device must inform the flight attendant if and where a drink or meal is available when it is lacking in the corresponding trolley.
- The device must provide flight attendants with information on who ordered something and what when passing their seat.
- Flight attendants would not need to ask every passenger if he ordered something and flight attendants would not need to remember the seat number of the passengers who ordered something. The information could be augmented when arriving at the right seat.
- The device must provide purser with information on the distribution of tasks and who currently is doing what.

Other functions

- The device must translate security instructions and any other information automatically in various languages.
- The device must automatically count the meals.

2.5.5 POTENTIAL FUNCTIONALITIES FOR A WEARABLE FOR THE CABIN CREW

Since the variety of potentials for a wearable that can be used by the cabin crew is very broad, the amount has been reduced to the few most interesting ones. The functions which have been dropped as well as the functions which have been kept are listed below:

Functions which have been dropped:

1. During the security checks must be highlighted green if they have been checked and everything is fine and areas that have not been checked must be highlighted red.
   - This function has been dropped since it does not seem to be feasible for this project; moreover, flight attendants use a checklist on which they highlight themselves which areas are already checked.

2. During the security check or when the passengers get off the airplane and it is checked whether someone forgot anything, objects that should not be there must be highlighted and an alert could be set off.
   - This function has been dropped since it does not seem to be feasible for this project; the product must be able to recognize how every single part of the airplane should look like and when a minor aspect differs from the original image, an alert would be set off. This could be disturbing for the flight attendants.

3. It must be highlighted when the trolley is ready to be picked out of the trolley box.
   - This function has been dropped since it is easier to solve this problem with integrating a signal, for example LED lights, into the trolley box.

4. It must be highlighted when the glasses, drinks or meals are not stored properly.
   - This function has been dropped since sensors would be needed which are integrated into the trolley. Since the trolleys are regularly cleaned by a washing system, the sensors would need to be very cheap or very robust. It is cheaper and also easier when the flight attendants check whether they stored the items properly.

5. It must be highlighted when a trolley is not stored properly in the trolley box.
   - This function has been dropped since it is easier to solve this problem with integrating a signal, for example LED lights, into the trolley box.

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

6. The device must inform flight attendants when the meals are ready.
   - This function has been dropped since not every flight attendant needs to be informed when the meals are ready and the responsible flight attendant can easily keep track on the timer of the meals.

7. The device must set off an alert when a drink is nearly empty.
   - This function has been dropped since the flight attendants can see when a drink is nearly empty, therefore sensors are unnecessary.

8. The device must provide purser with information on the distribution of tasks and who cur rently is doing what.
   - This function has been dropped since it would make the work of the flight attendants less efficient if they would constantly need to fill in what they are currently doing, so that oral communication is easier.

9. The device must translate security instructions and any other information automatically in various languages.
   - This function has been dropped since this function could be better solved by displaying the translations onto the screen on the aircraft.

10. The device must automatically count the meals.
    - This function has been dropped since it does not seem to be feasible for this project, and maybe it would be even less time efficient than counting the meal manually (for example, when codes needed to be scanned).

Functions which have been kept:

1. Not fastened seat belts or open bins must be highlighted.
2. The device must set off an alert when a passenger would like to drink some water during the guarding shift.
3. The device must provide flight attendants with information on the flight, workshops and emergency cases.
4. The device must provide information on passengers (name, date of birth, fly history, specific diet, language skills, seat number) for a more personalized service.
5. The device must provide information on which passengers could help out in case of an emergency.
6. The device must provide flight attendants with information on who ordered something and what when passing their seat.
7. The device must inform the flight attendant if and where a drink or meal is available when it is lacking in the corresponding trolley.
8. The device must provide information on how many glasses of which drink are needed or during on-board sales how many people order something and what.

2.5.6 POSSIBLE SOLUTIONS

To make the idea for a wearable for the cabin crew more concrete, it has been searched for possible solutions. The potential functions of the device as well as ideas for the corresponding solutions are listed in *table 2*.

Table 2: Solutions for functionalities of a wearable for the cabin crew

Function	Solution
1. Not fastened seat belts or open bins must be highlighted.	• The device could alert (flashlight, vibration, maybe even a sound) when a bin is still open or a seat belt is not fastened. ▷ Sensors in the seat belts and bins could communicate with the device
2. The device must set off an alert when a passenger would like to drink some water during the guarding shift.	• The passengers would also need a device or an app to inform the flight attendant that they would like some water. ▷ Could be a smart watch ▷ Could be an app on the passenger's smartphone ▷ Could be a user interface on the screen of the seat
3. The device must provide flight attendants with information on the flight, workshops and emergency cases.	• The device could have a database and a feature that allows the user to search for keywords or topics ▷ Could be in the form of smart glasses and the search feature could be voice controlled ▷ Could be in the form of a smart watch with a screen on which the user could type
4. The device must provide information on passengers (name, date of birth, fly history, specific diet, language skills, seat number) for a more personalized service.	• The passengers could inform the airline about their data when booking the flight. ▷ Information is saved on device and flight attendants have access to it ▷ The passengers could use a device or an app to inform the flight attendants about their data. ▷ Could be a smart watch ▷ Could be an app on the passenger's smartphone ▷ Could be a user interface on the screen of the seat

2.5 CONCEPT IDEA 4:
A WEARABLE FOR THE CABIN CREW

Function	Solution
5. The device must provide information on which passengers could help out in case of an emergency. open bins must be highlighted.	• The passengers could inform the airline about the fact that they could help out in case of an emergency when booking the flight. ▷ Information is saved on device and in case of an emergency the flight • attendants have access to the list ▷ The passengers could use a device or an app to inform the flight attendant that they could help out in an emergency. ▷ Could be a smart watch ▷ Could be an app on the passenger's smartphone ▷ Could be a user interface on the screen of the seat
6. The device must provide flight attendant with information on who ordered which meal when passing their seat.	• The device of the flight attendant could give a subtle alert (flashlight, vibration) when passing the seat of the corresponding passenger. ▷ QR code on the package of the meal could be scanned so that the seat number and other data is saved on the device (control points on the seats could inform the device about the position of the flight attendant)
7. The device must inform the flight attendant if and where a drink or meal is available when it is lacking in the corresponding trolley.	• The passengers could have a database on the device • The device could be able to scan codes on the items ▷ Could be a smart watch ▷ Could be smart glasses
8. The device must provide information on how many glasses of which drink are needed or during on-board sales how many people order something and what.	• The passengers would also need a device or an app to order their drink. ▷ Could be a smart watch ▷ Could be an app on the passenger's smartphone ▷ Could be a user interface on the screen of the seat

2.6 CHOICE OF CONCEPT IDEA

Based on the research and brainstorming for ideas for a wearable that is used in an aircraft cabin, a concept idea choice has been made. The chosen concept idea has been more detailed to become a full concept.

The first idea that has been excluded to become a more concrete concept is the device for prevention of spread of illnesses. Research on how the spread of illnesses in an aircraft cabin could be prevented showed that a wearable would not have an added value. Antibacterial textiles are still in development and not yet commercially available.
While they might be great to be used in hospitals, as for example for antibacterial bed linen, they are not well suited for the use in an aircraft cabin. For the assignment it is given that the airline that is going to offer the product to their staff or their clients should have a positive business case. Offering antibacterial clothing to the staff and the passengers would probably not result in a positive business case, because passengers are likely not to be reminded that there is a higher chance to get infected on an aircraft. Moreover, it does not seem to be challenging enough to design clothing made of antibacterial fabrics and the body parts that are most prone to be affected by bacteria are the mucous membranes. In order to prevent bacteria from settling down, the mucous membranes must be protected.

This could be done by designing a face mask made of antibacterial textile, but a face mask would be daunting for other passengers, since they could think that the wearer of the mask is very sick. Such a mask could be offered to staff and passengers who are sick, but in general sick staff should not be allowed to work and persons who have an infectious illness should not be allowed to get on board. All in all the spread of illnesses could be prevented by improving the ventilators of an aircraft and antibacterial materials may be used for the interior, but a wearable does not seem very promising to solve this problem.

The next idea that has been dropped is the device for improving sleeping behavior on an aircraft. Despite that many people are struggling to sleep on an aircraft, this problem cannot be completely solved by a wearable. Most find the seats too uncomfortable and many also cannot sleep well because of the surrounding noise and the movements of the aircraft. While the problem with the noise could be eliminated by a wearable, the others cannot be eliminated by such a device.
Furthermore, music and *bright light therapy* could help the passengers to fall asleep but such devices are already on the market and additionally there already is the possibility to listen to calming music on the aircraft. Therefore designing a device that improves the sleeping behavior on an aircraft would not be very valuable and not challenging enough for this assignment.

Also the idea to design a wearable that helps people to overcome their nervousness about flying has been dropped.
Though this topic would have been challenging enough, it might not fit into the assignment description. The goal of this assignment has been set to design a wearable that can be offered to airlines in the form of a business-to-business market. The device might be more a product to be sold on the consumer market than from business-to-business since people who feel nervous about flying might like to invest once into such a product. This way they could also start the treatment already before the flight, which would be more effective for them. Additionally, in this phase of the project it is still unclear if there would be an added value to design a device

2.6 CHOICE OF CONCEPT IDEA

against nervousness about flying as a wearable. More research and a more concrete concept would be necessary to determine if such a device would be better as a wearable than, for instance, as an application for smartphones or as a part of the aircraft interior.

The final idea is a device to be used by the cabin crew. Such a device could have various functions of which some definitely would be very valuable to be integrated into a wearable other than into the interior or a smartphone application. There is great potential to design some functionalities that do indeed improve the service and the efficiency of the work of the flight attendants. Such a product fits perfectly into a business-to-business market and it can also be combined with a smart cabin product line *Zodiac Aerospace* is currently working on. Thus, considering that a wearable for use for the cabin crew would be more successful on the market and does fit very well into the vision and plans of *Zodiac Aerospace*, it has been chosen to go on with this idea.

2.7 CONCEPT WEARABLE FOR THE CABIN CREW

2.7.1 FUNCTIONALITIES AND SOLUTIONS

Some of the functionalities that have been mentioned before have been dropped since a wearable might not be the simplest and best solution. The functionalities that have been dropped are:

- The device must provide information on how many glasses of which drink are needed or during on-board sales how many people order something and what.
- The device must set off an alert when a passenger would like to drink some water during the guarding shift.

The first and second function might be solved in an easier and more effective way, for instance, by displaying the orders on a screen in the galley instead of on a small screen of a wearable, since the orders need to be prepared in the galley anyway.

Although some functions have been dropped, a variety of functions has been kept:

1. Not fastened seat belts or open bins must be highlighted.
   - The flight attendants could immediately see which seats and bins need to be checked, so they would not need to check every seat and every bin. Currently, when a passenger is sleeping and turbulences arise, they need to be waked if their seat belt is hidden under a blanket in order to check if the passenger wears it. This could be avoided by this function.

2. The device must provide flight attendants with information on the flight, workshops and emergency cases.
   - When there is an emergency, a flight attendant should always know what to do. In case a flight attendant has a blackout, he or she can look up the needed information.

3. The device must provide information on passengers (name, date of birth, fly history, specific diet, language skills, seat number) for a more personalized service.
   - A personalized service makes the passengers feel more comfortable and the passenger experience is improved.

4. The device must provide information on which passengers could help out in case of an emergency.
   - When there is an emergency, flight attendants currently ask if a passenger is qualified to help them out. When those passengers are listed on the device, they could directly ask the right passengers for help.

2.7 CONCEPT WEARABLE FOR THE CABIN CREW

5. The device must provide flight attendants with information on that someone made an order and who ordered what when passing their seat.
   - ▷ The flight attendants would not need to ask every passenger whether he ordered something and what. This is more time efficient and convenient for both, the passengers as well as the flight attendants.

6. The device must inform the flight attendant if and where a drink or meal is available when it is lacking in the corresponding trolley.
   - ▷ By offering this function, the flight attendants would not need to run around on the aircraft in order to find the right item. This is less stressful for them and also more time efficient.

Moreover, two new functions have been added:

7. The device must help to communicate with passengers who speak another language.
   - ▷ This function is inspired by the function to translate safety instructions into various languages. Sometimes, passengers do not speak a second language and in order to communicate with them, a real-time translation function that works for both conversational partners, the passenger and the flight attendant, would be useful.

8. The device must provide flight attendants with information on special diets. For example what exactly is veganism, what does kosher mean etc.
   - ▷ This function has been added to improve the passenger experience for passengers who follow a special diet. Although, they order *special meals*, there are no special snacks on board and drinks can also be non-vegan or the like. When the flight attendant knows what a certain diet implies, he could inform the passenger which items are suited and which are not. This way the passenger would not need to ask for every ingredient etc.

2.7.2 POTENTIAL DEVICES FOR THE WEARABLE

The functions listed before could work on various devices. At the end of this chapter, a choice for a device is made. In the beginning, three potential devices have been considered: *Google Glass*, *Microsoft HoloLens* and a smartwatch with a big screen such as *Androidly*. These devices were considered since they are all able to display information, which is needed for the functions mentioned before. Other devices which are able to display information and are mentioned in paragraphs 1.2.2 and 2.5.2 are the *Sony Smart Watch, Samsung Galaxy Note 3* phablets, smartphones, mobile apps loaded onto *iPhone 6 Plus*, and *Apple Watch*.

The two smartwatches are used for storing boarding passes and receiving information on the flight. Therefore, they only have a small screen which is not suited for the mentioned functions. The phablets, the smartphones, and the apps for the *iPhone* are not wearables so they do not fit into the assignment description.
Thus, the three potential devices are described below. Although *Glass* and the *HoloLens* have been mentioned before, they are now explained a little more detailed.

Google Glass

Google Glass (figure 2.7) is a wearable computer developed by the company *Google*. The smart glasses are worn just like regular glasses and enable the user to operate hands-free. In 2013, the device became available for beta testing. *Google* planned to make *Glass* commercially available in 2014 but because of many negative reactions concerning *Google Glass* the company decided to only sell *Glass* to enterprises.
The device has a heads-up display in the corner above the wearer's right eye. In this way, information is placed directly into the wearer's field of vision. *Glass* enables 'the user to browse the internet, obtain directions to locations, send text messages, take pictures and more' *(Goodrich, 2013)*. Additionally, there are various applications with a range of other functionalities like *facial recognition*, QR code scanning, or translation apps like *Word Lens*. *Word Lens* scans and translates words written on, for example, a street sign and then overlays the sign with the translation like shown in *figures 2.8.1* and *2.8.2 (Swider, 2017)*.

An important functionality of the wearable is *voice recognition* enabling the user to control the

Figure 2.7: Google Glass

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device by verbal commands. Since not everything can be controlled by verbal commands, *Glass* also has a touchpad on its right side *(Goodrich, 2013)*.

Figure 2.8.1: Scanning foreign-language street sign with Word Lens

Figure 2.8.2: Overlaying foreign-language street sign with translation

Microsoft HoloLens

Microsoft's *HoloLens (figure 2.9)* is an augmented reality headset. In much the same way as *Glass*, the *HoloLens* will project virtual images into the user's field of vision, but while *Google Glass* only creates 2D images, *HoloLens* creates virtual 3D models *(Roberts, 2016)*. By blasting light at the eyes of the wearer, the holograms are created. The user can also interact with these images since the device tracks the wearer's movements, hand gestures and gaze. With its camera, the environment is scanned to locate objects so that the holograms interact naturally with the environment *(Statt, 2015)*.

Moreover, the user is able to 'capture videos and photos of the holographic exploits' *(Roberts, 2016)*. Just like *Google Glass*, the device can be voice-controlled but it is much heavier than *Glass* and also it has not such a sleek design.

The device is especially used for gaming, but other applications are possible *(Roberts, 2016)*. For example, maintenance could be made way easier with the *HoloLens*. By accessing the camera on the *HoloLens* to see through the wearer's eyes, instructions on how to repair, for instance, an engine could be given from a distance *(Statt, 2015)*. Moreover, *Microsoft* 'is partnering with other companies to use *HoloLens* in practical ways.

Volvo is expected to bring the technology to its car showrooms where customers will be able to view different color options for their chosen car and see safety features in action' *(Roberts, 2016)*. The development edition of the *HoloLens* costs $3,000 allowing 'developers to start making games and apps for the forthcoming headset' *(Roberts, 2016)*.The commercial suite edition costs $5,000 and comes with the 'development

edition hardware, plus a warranty and enterprise features for added security and device management' (*Microsoft, n.d.)*.

Figure 2.9: Microsoft HoloLens

Figure 2.10: Androidly smartwatch

Smartwatch like Androidly

The *Androidly* smartwatch, shown in *figures 2.10* and *2.11*, is *Android* powered and has a large two inch touchscreen (320 x 240 pixels). The device is 14mm thick and weighs 160 grams *(Woods, 2013)*. It can run apps that are designed for *Android (SmartWatches.org, n.d.)*, so it is very similar to a regular smartphone. It also has Wi-Fi, a camera *(Woods, 2013)*, Bluetooth, GPS and 'includes 4GB of internal storage with support for up to 16GB of external storage' *(SmartWatches.org, n.d.)*. Unlike most smartwatches, *Androidly* functions as a freestanding device, so it is not dependent on a smartphone *(Pramis, 2013)*. To control the device, buttons are used that are placed around the outer shell of the smartwatch. In comparison to *Glass* and the *HoloLens*, *Androidly* is very cheap since it only costs $219 *(Woods, 2013)*.

Figure 2.11:Androidly on wrist

2.7 CONCEPT WEARABLE FOR THE CABIN CREW

2.7.3 SOLUTIONS PER FUNCTION

In the following, the possible solutions for each function which are listed in paragraph 2.7 on page 61 are presented. For now, the solutions do not depend on a certain kind of device. After the possible solutions have been considered, the device has been chosen based on the advantages and disadvantages in general and per function.

Function 1:
Not fastened seat belts or open bins must be highlighted

Seat belt reminders:

When thinking of a possibility to inform the flight attendants that a passenger is not wearing a seat belt during turbulences, the first solution that comes to mind are seat belt reminders as they are used in cars. Seat belt reminders consist of three main components:

1. A system that determines whether a seat is occupied
2. Sensors in the buckle of the seat belt to determine whether a seat belt is latched
3. An alarm to remind the car passengers to lock their seat belt

1. The system that determines whether a seat is occupied or not is the Occupant Classification System (OCS). The system consists of a range of sensors as shown in *figure 2.12* and can determine if someone is sitting in the passenger seat and whether it is an adult or a child. In this way the need to switch airbags on or off is eliminated *(George, 2008)*. For the seat belt reminder on an aircraft it is not relevant whether an adult or a child is sitting in the passenger seat, so only the pressure sensor of the OCS is relevant for a seat belt reminder system.

Usually, an OCS can be built into the passenger seat in the form of a sensor mat, so this system part could be outsourced. This part is built in by the car's manufacturer; therefore not many evidence could be find on the costs of a sensor mat. However, one example has been found that could give an impression. An OCS sensor mat that was removed from a *BMW* is sold on the internet for £64.50 *(ASWR, 2017)*. Such a sensor mat has more sensors than it is needed for an aircraft and moreover, when ordering a large amount of the sensor mats, a discount will be given. Therefore, the costs are estimated to be lower than the mentioned price.

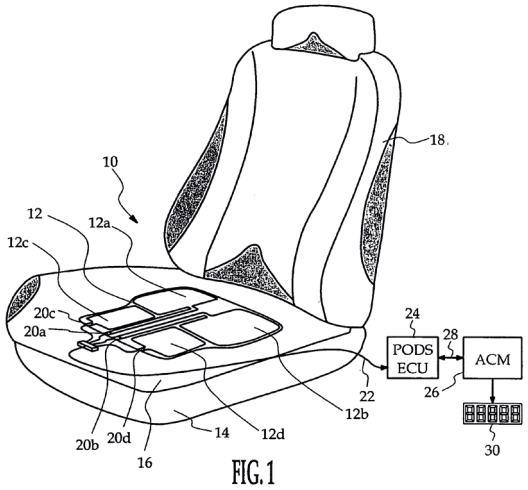

Figure 2.12: Delphi OCS

2.1. To determine whether a seat belt is latched or not, there are two different possibilities. For the first one, a Reed Switch sensor is used. For the principle of a Reed Switch, two components are necessary: the Reed Switch sensor and a magnet.
The seat belt buckle thorn acts as magnet and the sensor is integrated into the main buckle housing as shown in *figure 2.13.1*.
The basic principle of a Reed Switch sensor is that it is 'in a normally open position' *(Littlefuse, 2017)* and when the seat belt is latched, the seat belt buckle introduces a magnetic field that activates 'the Reed Switch to close its contacts sending a voltage output to the customer's electrical interface' *(Littlefuse, 2017)*, as shown in *figure 2.13.2*. The voltage output of the Reed Switch ensures that the alarm of the seat belt reminder system is switched off.

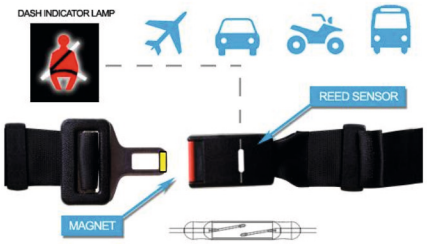

Figure 2.13.1: Reed Switch sensor in an unlatched seat belt

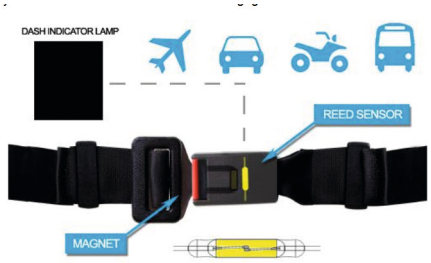

Figure 2.13.2: Reed Switch sensor in a latched seat belt

2.2. The second possibility to determine whether a seat belt is latched or not is to use a Hall Effect sensor. Just like a Reed Switch, a Hall Effect Sensor is activated by an external magnetic field. The two important characteristics of a magnetic field are the flux density and the polarity. The output signal from a Hall Effect sensor depends on the magnetic field density around the device. So when the magnetic flux density exceeds a certain threshold, the sensor generates an output voltage.

A Hall Effect sensor consists of a p-type semiconductor material that constantly passes current through itself *(Electronics Tutorials, n.d.)*. A p-type semiconductor is a doped semiconductor crystal. The dopants of a p-type semiconductor 'can catch an additional outer electron, thus leaving a hole in the valence band'. In this way, the electrons become mobile *(Laube, n.d.)*. When being exposed to a magnetic field, a force is exerted on the semiconductor leading to a deflection of the charge carriers.
These charge carriers, the electrons and the holes, move into the opposite direction. When they move a 'potential difference is produced between the two sides of the semiconductor material' producing the output voltage. This output voltage might be very small, so the sensors sensitivity might need to be improved. That is why most Hall Effect devices have 'built-in DC amplifiers, logic switching circuits and voltage regulators' *(Electronics Tutorials, n.d.)*.

Application on an aircraft:
Such a system, as described above, could also be used on an aircraft to inform the flight attendants which passengers are not wearing their seat belt. When a seat belt is not worn during turbulences, the sensor could send a signal to the flight attendants' devices, informing them at which seats the seat belt is not worn, while

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they are going through the aisle. This information could be augmented directly into the field of vision of the flight attendants by making use of *Google Glass* or *Microsoft HoloLens*, but it could also be displayed on the screen of a smartwatch.

Additionally, the system could also be used for bins that are not closed properly. By integrating a sensor and a magnet into the bins, a signal could be sent to the wearable when a bin is still open and the information could then, again, be augmented into the flight attendant's field of vision or it could be displayed on the screen of a smartwatch.

For the aircraft, a Hall Effect sensor would be better than a Reed Switch. The life expectancy of a Reed Switch is limited up to 1 billion operations while the life expectancy of a Hall Effect sensor is unlimited. The seat belts as well as the bins of an aircraft are used very often, so a Hall Effect sensor is more efficient in terms of maintenance. Moreover, Hall Effect sensors are not susceptible for vibrations and shocks and since an aircraft moves a lot, this is a relevant requirement for a sensor *(Standex-Meder Electronics, 2013)*. Reed Switch sensors as well as Hall Effect sensors are both not that expensive. As it is calculated in *appendix E* on page 123, the average costs of a Reed Switch are €4.23 and the average costs of a Hall Effect sensor are €3.71. So, in terms of costs, Hall Effect sensors are also a little cheaper than Reed Switches.

Function 2: The device must provide flight attendants with information on the flight, workshops and emergency cases

The device could have a database with information on every workshop the flight attendants have had and also extra information on special kinds of emergencies and the like. By using a voice command the smart glasses could search for keywords or topics just like it would '*google*' the information. When wearing a smartwatch, the flight attendant might also use voice-command, but then it would also be possible to insert a certain keyword into the device.

Function 3 and 4: The device must provide information on which passengers could help out in case of an emergency and general information on passengers for a more personalized service

Facial recognition:
At the beginning of the development of *Google Glass*, the product should have a function called *facial recognition*. Later, *Google* banned that function due to privacy concerns *(Arthur, 2013)*. *Facial recognition* refers to the functionality to be able to identify a person from, for example, an image or a video, or in the case of *Google Glass*, when looking at the person.
Although *Google* stated in 2013 that *facial recognition* would not be approved at that time *(Art-*

hur, 2013), they did not say that it never will be approved.

Moreover, the function could only be integrated for the glasses worn by airline staff to improve the service. Airline passengers could voluntarily give some information on themselves to the airline when booking a flight and when they want the flight attendants to use this information to improve the service, they can check a box on the airline's website to confirm that the staff is allowed to use *facial recognition* for them.

The data could then be saved and when a passenger confirmed *facial recognition*, his personal data could be augmented into the flight attendant's field of vision for making the service more personal. Part of the data could also be if the passenger is able to help out in case of an emergency. When a passenger states that he could help out in case of an emergency but does not want to confirm that *facial recognition* might be used on him, *Glass* could just save this data and the seat number of the corresponding passenger.

Function 5: The device must provide flight attendants with information on that someone made an order and who ordered what when passing their seat

Even when a screen in the galley shows which orders have been made, it is necessary for the flight attendants that orders actually have been made. So every time someone makes an order, the flight attendants need to be informed. When using *Glass* or the *HoloLens*, this information could be augmented as a message into the flight attendants' field of vision. When using a smartwatch, a text message could be sent to the device and to call the flight attendant's attention to the device, it could gently vibrate.

In order to inform the flight attendants about the order of a certain passenger when passing his seat, the device must be able to locate the corresponding seat. The seats then must have sensors that communicate with the system. These sensors are needed anyway, to locate open seatbelts. If the wearable is used in the *Connected cabin*, the *hospitality* screens already have location sensors that communicate with the device. When using one of the smart glasses, the information could be augmented into the flight attendant's field of vision and when using a smartwatch, the device could vibrate and inform the flight attendant about the order with a text message on the device's screen.

Function 6: The device must inform the flight attendant if and where a drink or meal is available when it is lacking in the corresponding trolley

Product recognition:
Product recognition refers to the 'process by which a product is automatically recognized within an image or video' *(Digitalmarketing, 2014)*. This functionality could be used by *Glass* and *HoloLens* to scan empty products so that the device can identify the product to inform the flight attendant where it can be refilled. That is much easier than a voice command or scanning a barcode or QR code on the product. Just by looking at the product, the device can tell the user if and where he can find a refill. The feature could also

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be integrated in a smartwatch, but it is less convenient than using it with smart glasses.

Scanning codes:
Since the meals that are served aboard are packed, *product recognition* is not a suited function to check if and where a certain meal can be found on the airplane. The solution could be QR codes or barcodes on the package of the meals. By scanning the code, the device could identify the product and tell whether the meal is still in stock and where the flight attendant can find it.

Automatic alert:
When the device is used in the *Connected cabin*, described in *appendix F* on page 126, the system automatically keeps track of the stock of the items. So the system exactly knows how many items are in a certain trolley. When the orders are made and a certain meal is out of stock in the corresponding galley, it is automatically ordered from another one. This way, the device only needs to keep track on which passenger ordered which meal.

Function 7:
The device must help to communicate with passengers who speak another language

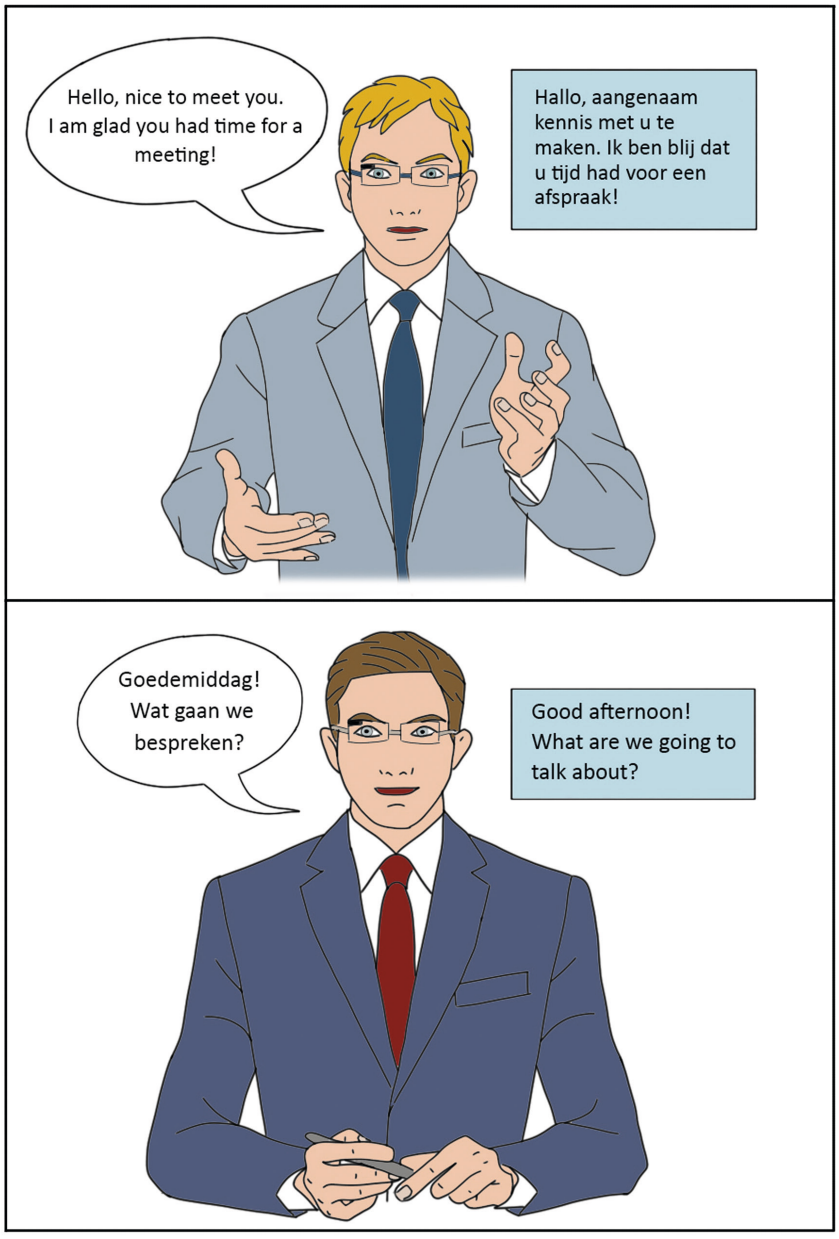

Figure 2.14: Storyboard Mite

Multillect Mite:
The company *Multillect* developed an application for *Google Glass*, namely the translator app *Mite*. When, for instance, two people have a conversation but they both speak another language, they can still talk to each other in their mother tongue. When both are wearing a *Google Glass* and they are using *Mite*, everything they say is translated into the conversational partner's native language and it is augmented as written text before the user's eyes *(Multillect, 2014)* as shown in the short storyboard in *figure 2.14*.

Skype translator:
The computer program Skype has a functionality called *Skype Translator*. When using the program, the user can select a contact and click on the *Translator Button* to adjust the language of this contact *(figure 2.15.1)*. When calling with each other, everything is translated into the user's mother tongue. The translations are displayed as text messages and they are read out loud. An example is shown in *figures 2.15.2* and *2.15.3*.

Figure 2.15.1: Translator Button

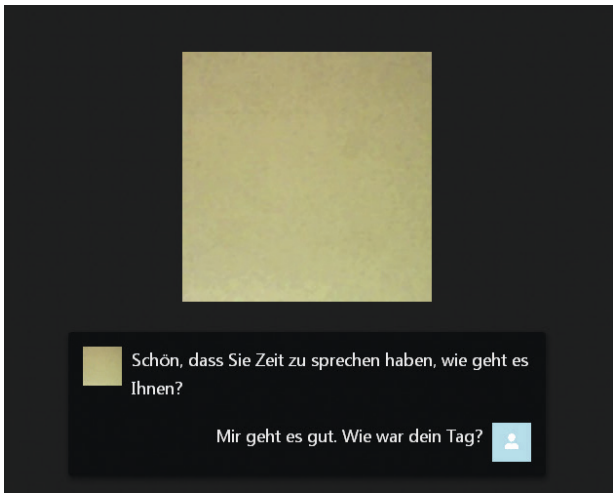

Figure 2.15.2: Skype Translator in German

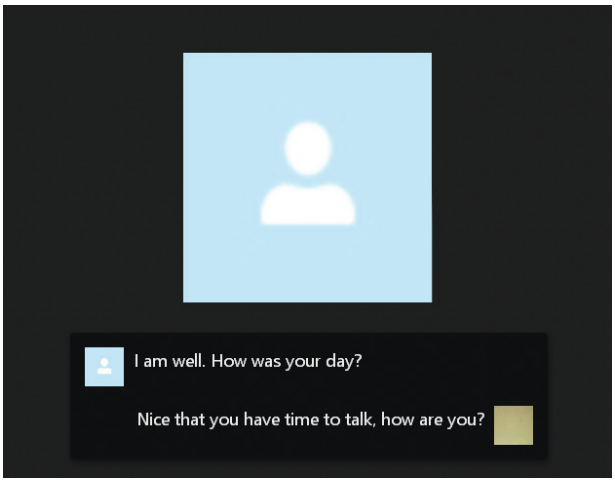

Figure 2.15.3: Skype Translator in English

Phonetic spelling:
Another possibility could be that the device shows the translation for the passenger as a text in phonetic spelling so that the flight attendant could read it to the passenger. This interaction would be more personal but also way more complicated.
At first, the flight attendant would need to say what he or she wants to be translated and then the device would translate it into phonetic spelling and again, the flight attendant would need to read the text out loud. Meanwhile, the passenger would not know what is going on, since the flight attendant would continue talking in his or her mother tongue. The passenger might not know that the flight attendant does not talk to him but to the device, so that might be a confusing situation.

Function 8:
The device must provide flight attendants with information on special diets

For flight attendants it might be very handy to know what a certain diet actually means. Usually people do not exactly know what, for instance, a kosher or vegan meal exactly is. When handing out snacks and drinks the flight attendants would be able to look up if a snack is suited for the passenger who is following a certain kind of diet. If it is not suited the flight attendant can immediately tell the passenger that he cannot eat that snack. In this way, the passenger does not need to ask for more information on the snack himself, so the passenger experience is improved.

Just like in function number four, the device could have a database with information on various kinds of diets. Then, when using smart glasses, the device could search for information on a certain diet by giving voice commands and when wearing a smartwatch, the flight attendant would additionally be able to insert a certain keyword into the device.

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2.7.4 COMPARISON OF THE DEVICES

In order to be able to make a qualified decision for the kind of device that is used to fulfill the functionalities, the three different devices named earlier are compared. The general and functionality specific advantages and disadvantages are listed in *table 3*. Function number two and eight have been left out since they would work even well on each of the devices. The weighting of each advantage and disadvantage is given with one, two or three plusses or minuses. Every plus and every minus counts one point. The advantages and disadvantages are then summed up to only get a single number. The device with the highest score is the best one regarding the advantages and disadvantages. F refers to function and G refers to general, for instance F1 is function 1 and G1 is general 1.

Table 3: Comparison advantages and disadvantages

Google Glass		HoloLens		Smartwatch	
Advantages	**Disdvantages**	**Advantages**	**Disdvantages**	**Advantages**	**Disdvantages**
F 1: information on which passengers do not wear a seat belt is directly augmented into the flight attendant's field of vision	F 1: the device must be able to recognize and locate the seats	F 1: information on which passengers do not wear a seat belt is directly augmented into the flight attendant's field of vision	–	–	–
++	-	++			
F 3+4: Information on passengers is directly augmented into the flight attendant's field of vision	F 3+4: *Facial recognition* feature requires that the camera is constantly filming	F 3+4: Information on passengers is directly augmented into the flight attendant's field of vision	F 3+4: *Facial recognition* feature requires that the camera is constantly filming	–	–
+	---	+	---		

2.7 CONCEPT WEARABLE FOR THE CABIN CREW

Google Glass		HoloLens		Smartwatch	
Advantages	**Disdvantages**	**Advantages**	**Disdvantages**	**Advantages**	**Disdvantages**
–	–	–	–	F 5: A gentle vibration to inform the flight attendant that they are just arriving at the right seat works better than information suddenly popping up in front of the flight attendant's eyes +	–
F 6: *Product recognition* and QR code scanning can be done very easily by only looking at the device ++	–	F 6: *Product recognition* and QR code scanning can be done very easily by only looking at the device ++	–	–	F 6: *Product recognition* and QR code scanning is a bit more complicated with a device worn on the wrist -

Google Glass		HoloLens		Smartwatch	
Advantages	**Disdvantages**	**Advantages**	**Disdvantages**	**Advantages**	**Disdvantages**
F 7: translation is directly augmented into the flight attendant's field of vision	–	F 7: translation is directly augmented into the flight attendant's field of vision	–	–	F 7: flight attendants needs to speak into the smartwatch for a proper translation
+		+			- -
–	G1: Passengers might feel uncomfortable seeing the whole cabin crew wearing such a device	–	G1: Passengers might feel uncomfortable seeing the whole cabin crew wearing such a device	G1: Passengers barely recognize a smartwatch and if they do, they still know what the flight attendant is currently looking at	–
	- -		- -	+	
–	G2: Device is not universal if the flight attendant needs prescription glasses	–	G2: Device is not universal if the flight attendant needs prescription glasses	G2: Device is universal for every flight attendant	–
	- -		- -	+	
–	G3: Device is quite expensive	–	G3: Device is quite expensive	G3: Device is quite cheap	–
	-		- -	+	

2.7 CONCEPT WEARABLE FOR THE CABIN CREW

Google Glass		HoloLens		Smartwatch	
Advantages	**Disdvantages**	**Advantages**	**Disdvantages**	**Advantages**	**Disdvantages**
–	G4: It is unclear if *Google* continues developing *Glass* --	G4: *HoloLens* is quite new and *Microsoft* will not stop the development in the near future ++	G4: It is unclear when *HoloLens* will be fully developed so that it could be used by flight attendants ---	G4: An *Android* based smartwatch already is fully developed and *Android* will not stop developing updates in the near future ++	–
G5: *Glass* has a sleek design and is lightweight +	–	–	G5: *HoloLens* is very heavy and big ---	G5: The positioning of the device on the wrist is more comfortable than smart glasses ++	–
–	G6: *Glass* does not have a good battery --	–	–	–	–
Sum: 7	Sum: 12	Sum: 8	Sum: 15	Sum: 8	Sum: 3
Score: -5		Score: -7		Score: 5	

2.7.5 CHOICE OF THE DEVICE

Regarding the comparison of the advantages and disadvantages of each device, the smartwatch has as many advantages as the *HoloLens* and one more than *Glass*. Unlike the two smart glasses, the smartwatch only has a few disadvantages while the smart glasses have more disadvantages than advantages. The result is a negative score for the glasses and a positive score for the smartwatch.

At its current development stage, the *HoloLens* definitely is not suited to be used as a device for the cabin crew. It is way too heavy and too big and would be daunting for the passengers. It is hard to foresee if and when the *HoloLens* will be sufficiently developed to be suited as a device that could be used by the cabin crew to improve the service on board.

A smartwatch can help the flight attendants to perform their tasks more efficiently than it is done right now. Anyway, *Google Glass* might be even more efficient due to its great features such as *facial recognition* and augmenting information directly into the user's field of vision; but it has too many important disadvantages, so that it would not be the best choice.

An important disadvantage is the battery of *Glass*. During the daily use the battery only lasts up to five hours and when using the video function, which is needed for *facial recognition*, the battery drains empty in less than an hour *(Future Publishing Limited Quay House, 2017)*. Additionally, using *facial recognition* would also result in privacy concerns and it would be hard to persevere that the passengers are constantly being filmed. Moreover, the flight attendant wearing the device would constantly being monitored. Everything he or she is looking at and everything he or she is doing would be filmed. Another important disadvantage is that the device might be daunting for passengers. Since the device should be used for improving the passenger experience, it would be bad when it does the opposite thing, namely worsen the passenger experience.

Summing up, the best choice for a wearable to be used by the cabin crew is a smartwatch. As a product example the smartwatch *Androidly* has been used since this watch has a bigger screen than most smartwatches and additionally it is a standalone device.

For this assignment, it is chosen to design an own smartwatch, that could be developed by *Zodiac Aerospace*. *Androidly* could of course also be outsourced, so that only the applications would be developed by *Zodiac Aerospace*. However, developing an own device fits better into the concept of the company and moreover, the product can then be developed to exactly suit the functions *Zodiac Aerospace* wants it to have and to perfectly fit into the concept of the *Connected cabin*, described in *appendix E* on page 123, the company is currently working on. The basic principle of the *Connected cabin* is that all the objects in the cabin are connected with each other so that they can communicate, so that some procedures on board can be improved. The device can be designed in such a way, that it can also communicate with the objects in the cabin.

DETAILING PHASE

3.1 INTRODUCTION DETAILING PHASE

The result of the previous phase is a range of functions and the kind of the device. For the chosen device, a smartwatch, some of the functions mentioned in the second chapter are not suited very well and some other functions might not be feasible for this project. Therefore, in this chapter, the questions 'Which functions should the smartwatch have?' and 'How can these functions be realized?' are answered. To do so, the functions of the smartwatch have been defined and more detailed and then the look of the device has been determined.

3.2 FUNCTIONS OF THE SMARTWATCH

Not all of the functions mentioned before were detailed for the smartwatch. Some of them have been dropped:

- The device must help to communicate with passengers who speak another language.
  - This function has been dropped since a translation program requires a high speed internet connection. Currently, there are no high speed internet connections on an aircraft. However, in the future this might be a great option.
- The device must provide information on passengers (name, date of birth, fly history, specific diet, language skills, seat number) for a more personalized service.
  - This function has been dropped since information on passengers could only be provided on the screen of the smartwatch, so that the flight attendant would need to look at the screen in order to get the information on the corresponding passenger. This would be quite impersonal and impolite as well as unhandy.
- The device must provide information on which passengers could help out in case of an emergency.
  - This function has been dropped since the way how flight attendants currently ask passengers for help in case of an emergency is easier. Now, when there is an emergency on board, flight attendants ask all of the passengers if someone could help out. To make it a little more discrete, the idea was at first that passengers could give certain information to the airline when booking the flight. Since the function of giving private information to the airline has been dropped, the only question when booking a flight would be if the passenger could help out in case of an emergency. When there really is an emergency, it is easier to just ask for this information if needed.
- The device must provide flight attendants with information on special diets. For example what exactly is veganism, what does kosher mean etc.
  - This function has been dropped since it is not one of the most important functions. It would be much easier if the products would be marked as vegan or kosher etc.

3.2 FUNCTIONS OF THE SMARTWATCH

The functions that have been kept for detailing are:

1. Not fastened seat belts or open bins must be highlighted.
2. The device must inform the flight attendants if and where a drink or meal is available when it is lacking in the corresponding trolley.
3. The device must provide flight attendants with information on the flight, workshops and emergency cases.
4. The device must provide flight attendants with information on that someone made an order and who ordered what when passing their seat.

After these functions have been determined, it has been checked whether the smartwatch still is the best choice for a wearable for the cabin crew based on the advantages and disadvantages of the devices. Since the content of the table did not change, the reasons for the number of plusses and minuses can be found in *table 3* on page 73. However, the numbers of the functions have changed, so it is mentioned to which original number the function refers to in brackets. Again, the weighting of each advantage and disadvantage was given with one, two or three plusses or minuses. Every plus and every minus counts one point. The advantages and disadvantages are then summed up to only get the score of the device. This comparison is shown in *table 4*.

Table 4: Repetition comparison advantages and disadvantages

Google Glass		HoloLens		Smartwatch	
Advantages	**Disdvantages**	**Advantages**	**Disdvantages**	**Advantages**	**Disdvantages**
F 1 (1): ++	F 1 (1): -	F 1 (1): ++	–	–	–
F 2 (6): ++	–	F 2 (6): ++	–	–	F 2 (6): -
–	–	–	–	F 4 (5): ++	–
–	G1: --	–	G1: --	G1: +	–

3.2 FUNCTIONS OF THE SMARTWATCH

Google Glass		HoloLens		Smartwatch	
Advantages	**Disdvantages**	**Advantages**	**Disdvantages**	**Advantages**	**Disdvantages**
–	G2: --	–	G2: --	G2: +	–
–	G3: -	–	G3: --	G3: +	–
–	G4: --	G4: ++	G4: ---	G4: ++	–
G5: ++	–	–	G5: ---	G5: ++	–
–	G6: -	–	–	–	–
Sum: 7	Sum: 12	Sum: 8	Sum: 15	Sum: 8	Sum: 3
Score: -5		Score: -7		Score: 5	

As it can be seen in the table the smartwatch has most advantages, least disadvantages and therefore obviously the highest score. So for the chosen functions the smartwatch still is the best choice as a wearable for the cabin crew.

3.3 DETAILING OF THE FUNCTIONS

The next step was the detailing of the chosen functions. In the following it has been investigated how each of the functions can be realized regarding the chosen device.

Function 1: Not fastened seat belts or open bins must be highlighted

As mentioned in *appendix F* about the *Connected cabin*, it is planned that *ICONNZ* checks whther the seats are in the right position and whther the seat belts are fastened. If a passenger did not follow the instructions properly, the system recognizes this and informs the flight attendants which seats need to be checked, as shown in *figure 3.1*.

The same user interface is used for the smartwatch for a consistent design. Additionally, the position of the flight attendant is highlighted on the device's screen so that the flight attendant can locate the corresponding seats more easily. When passing a passenger who did not fasten his seat belt, or where the bin is still open, the device must inform the flight attendant to check that seat. For this, the device vibrates until everything is in the right position. The user interface of the smartwatch is shown in *figure 3.2*.

Figure 3.1: ICONNZ user interface for proper position of seats

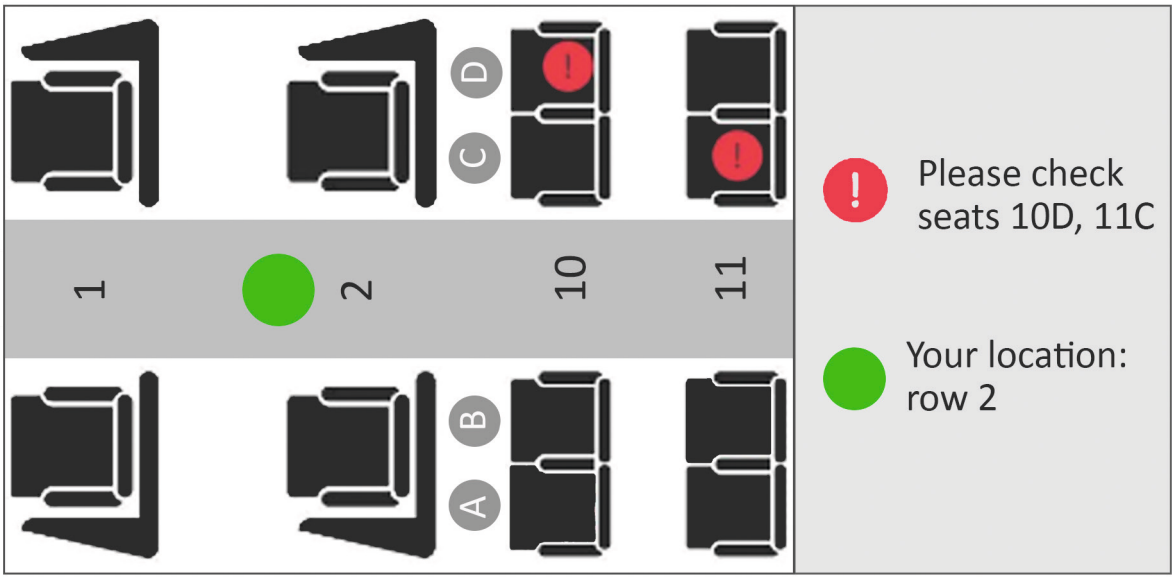

Figure 3.2: User interface bin and seat position check

3.2 FUNCTIONS OF THE SMARTWATCH

Function 2: The device must inform the flight attendant if and where a drink or meal is available when it is lacking in the corresponding trolley

In the *Connected cabin*, the device does only need to inform the flight attendants where a certain drink can be refilled, the meals are automatically ordered from another galley if they are out of stock in the corresponding galley.

However, in a usual cabin, the flight attendants must also check on where a certain meal is still in stock when it is lacking in their trolley. In order to do so, the flight attendants can open an application on their device called *stock inspection*.

On the screen they can then choose between *drinks*, *meals*, and *other* and then they can choose the corresponding item to see where it can be replaced.

When, for instance, the drink *Coca Cola* is empty and the flight attendant wants to know where he or she can find the nearest location to replace the empty bottle with a full one, the first step is to open the application, as shown in *figure 3.3.1*; the second step is to choose the right category, so in this case drinks, see *figure 3.3.2*; the third step is to choose the right item, which is *Coca Cola* as shown in *figure 3.3.3*; and then, it is shown where the drink can be replaced. All of the locations are listed on the device beginning with the nearest location and ending with the furthest location, see *figure 3.3.4*.

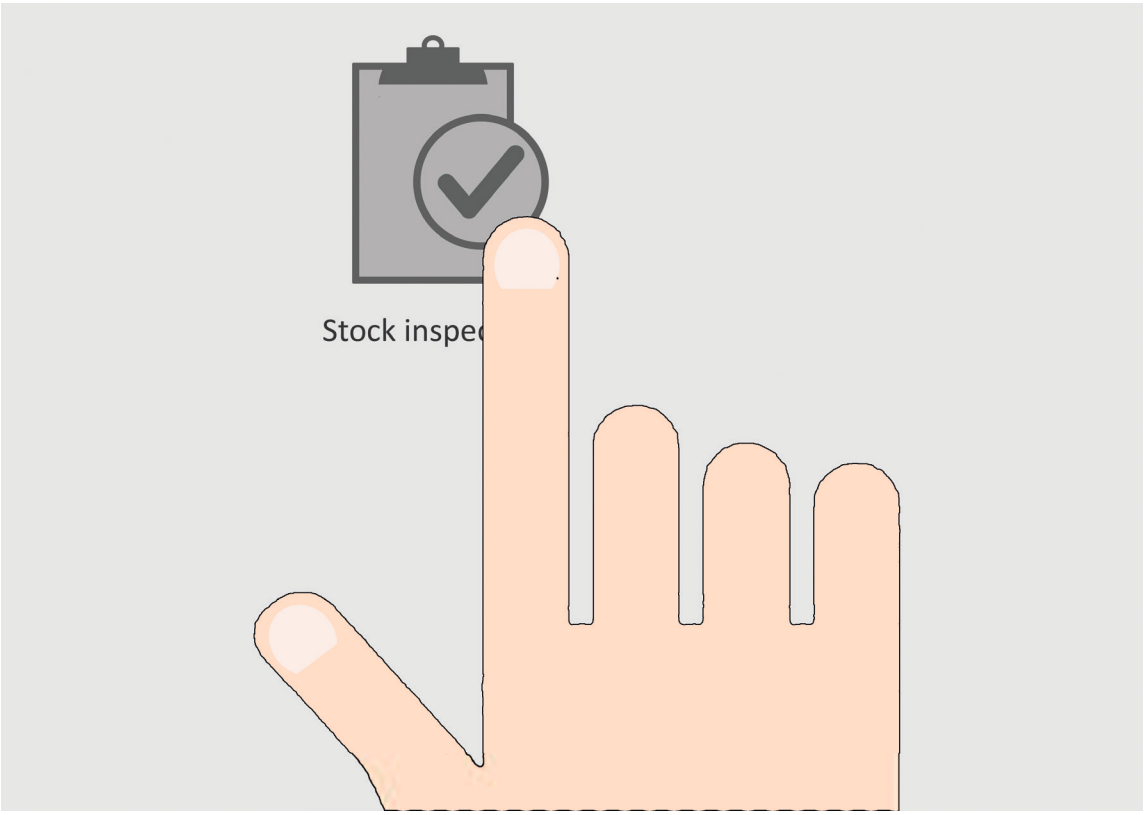

Figure 3.3.1: Open Stock inspection

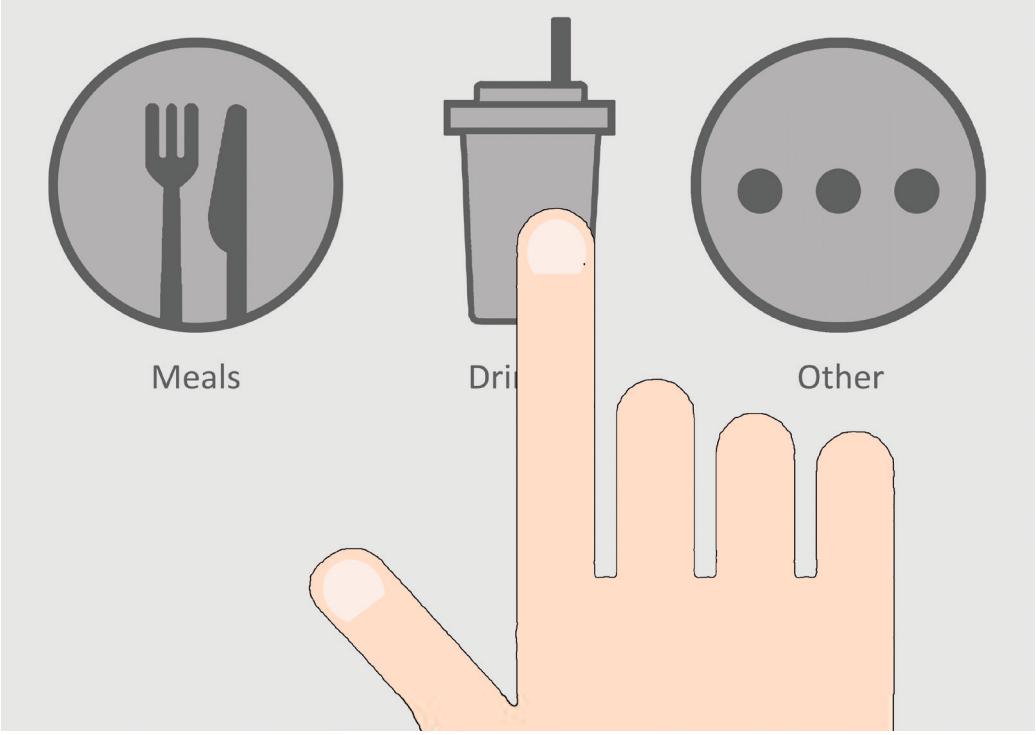

Figure 3.3.2: Choose category

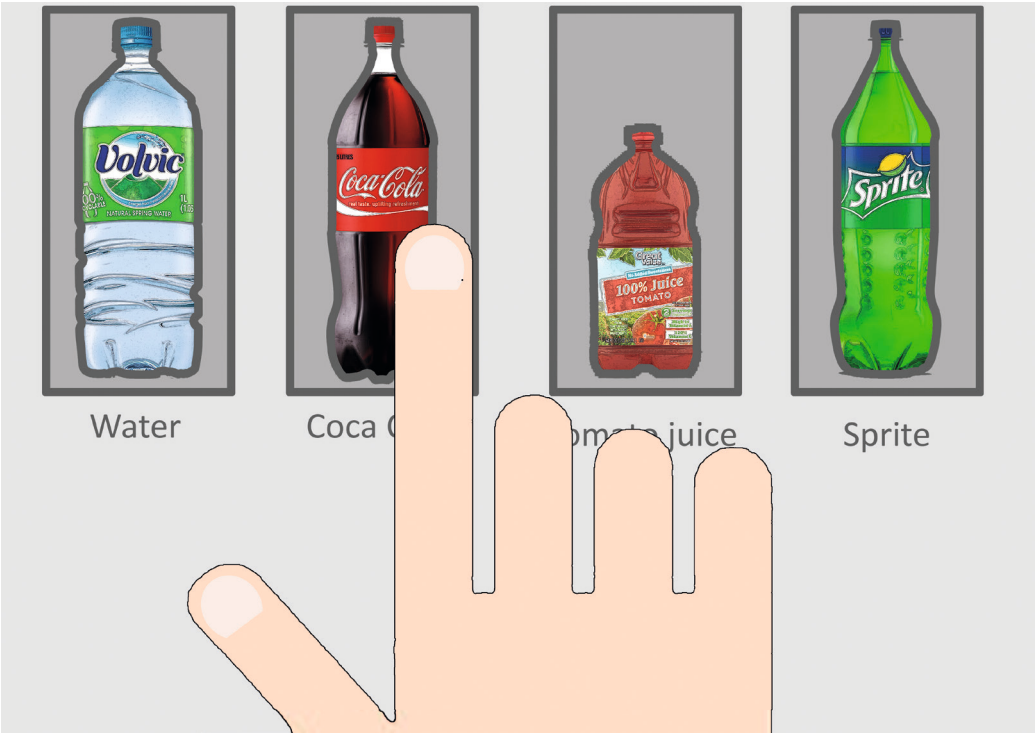

Figure 3.3.3: Choose item

3.2 FUNCTIONS OF THE SMARTWATCH

Figure 3.3.4: List of replacement locations

Function 3: The device must provide flight attendants with information on the flight, workshops and emergency cases

Flight attendants have a lot of different workshops and they have to remember many information. When something unusual happens, like an emergency on board, they might struggle with remembering the necessary instructions. Of course, this should not happen and it usually does not happen, but in case of an emergency the risk should not be taken that any flight attendant is unsure what to do. So, in the unlikely event that there is an emergency and the flight attendant has a blackout, he or she can look up what to do in the database of the device.
To do so, the flight attendant opens the application *database* and a search box appears in which he or she can look up a certain keyword or topic, see *figure 3.4.1* and *3.4.2*. Alternatively, there is a menu button in the top right corner. By selecting the button, a box with the different chapters expands and the corresponding chapter can be selected as shown in *figure 3.4.3*.

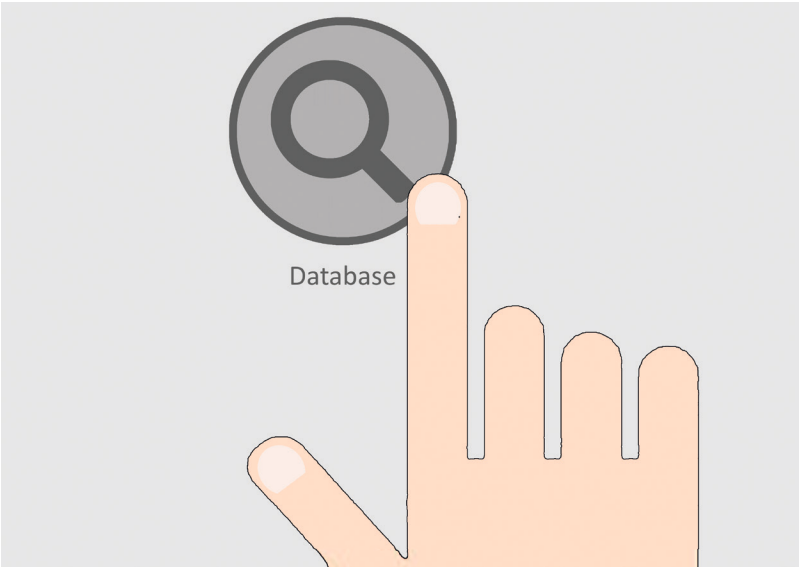

Figure 3.4.1: Open Database

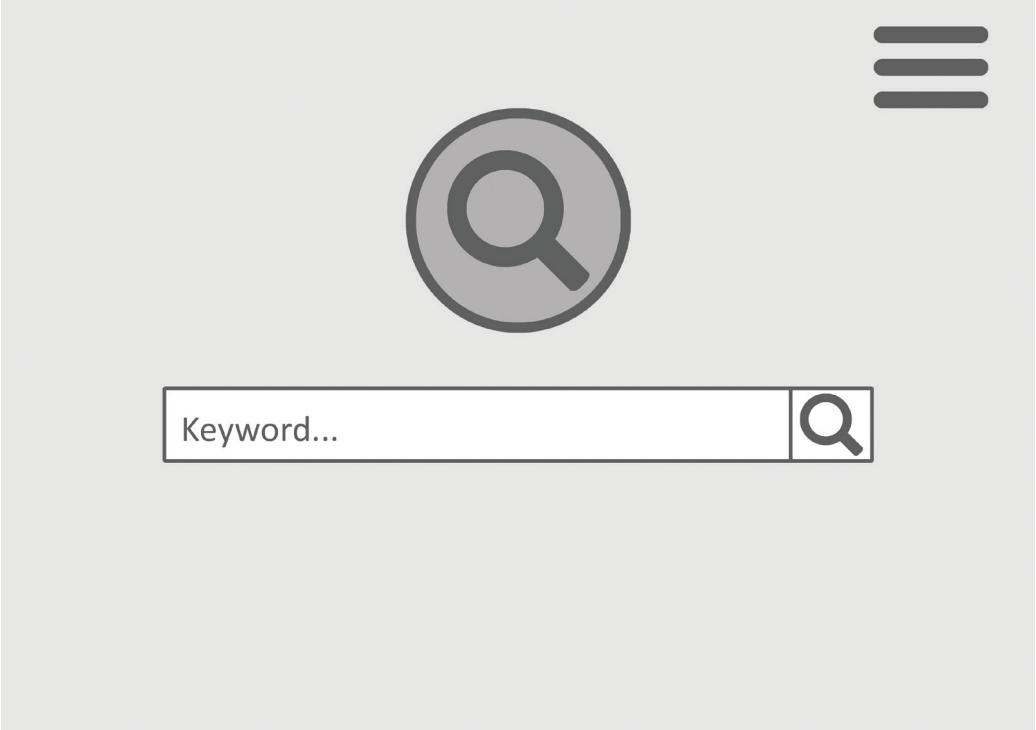

Figure 3.4.2: Looking up keyword

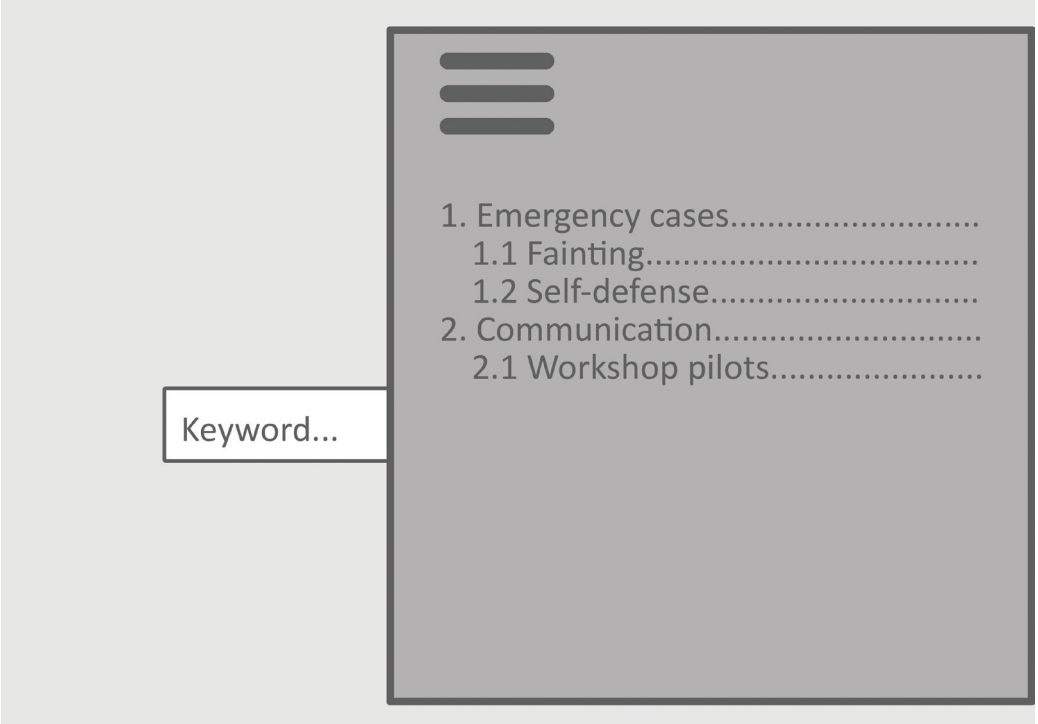

Figure 3.4.3: Expanded menu with chapters

3.2 FUNCTIONS OF THE SMARTWATCH

Function 4:
The device must provide flight attendants with information on that someone made an order and who ordered what when passing their seat

To make it more convenient for the flight attendants to receive orders and to hand out the ordered items, the device is able to inform the flight attendant about orders that have been made.

A text message is sent to the device every time an order has been made, shown in *figure 3.5*, and additionally, the device will vibrate. Then, a screen in the galley shows how many and which items have been ordered. When everything is prepared, the items need to be handed out. It is unnecessary for the flight attendant to remember who ordered which item thanks to the smartwatch.

The smartwatch shows the location of the flight attendant and the passengers who ordered something on the screen *(figure 3.6)*. When the flight attendant arrives at a passenger who made an order, the device vibrates and displays the seat number and which item has been ordered on the screen, see *figure 3.7*.

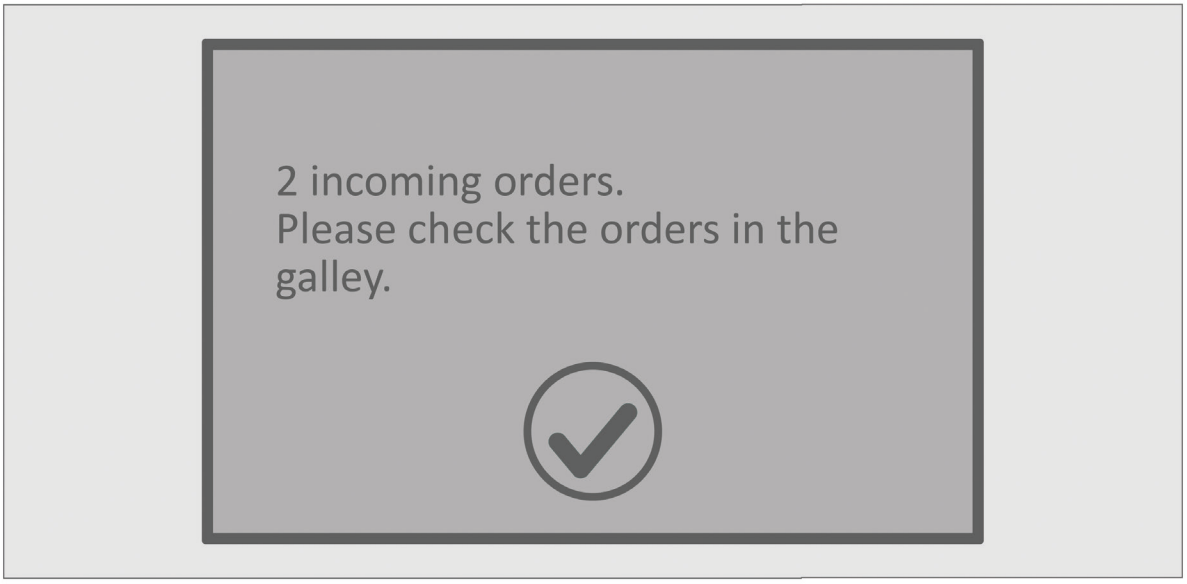

Figure 3.5: User interface when informing about incoming orders

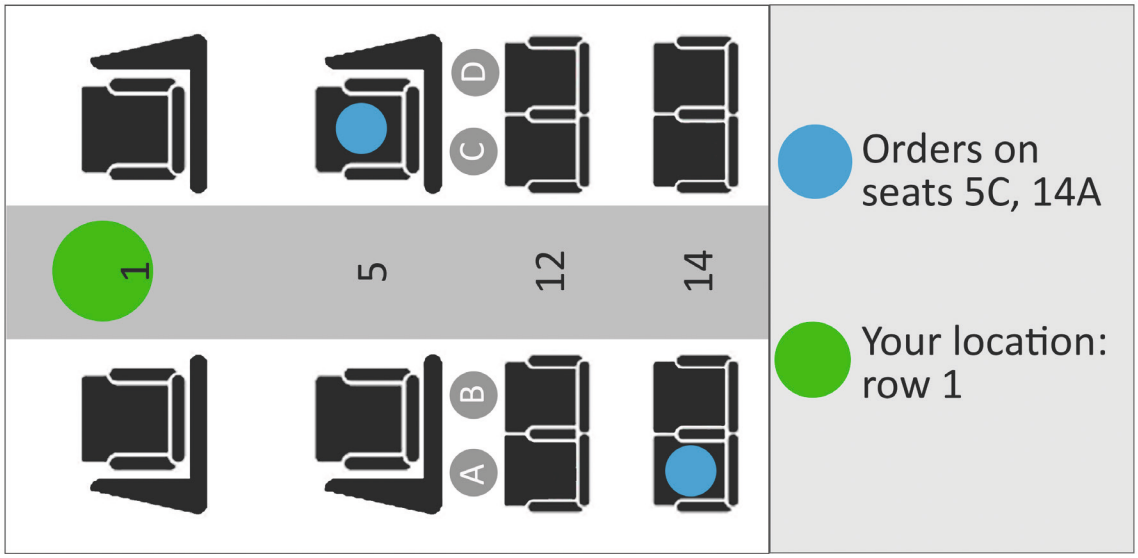

Figure 3.6: User interface with location of the flight attendant and the passengers who made an order

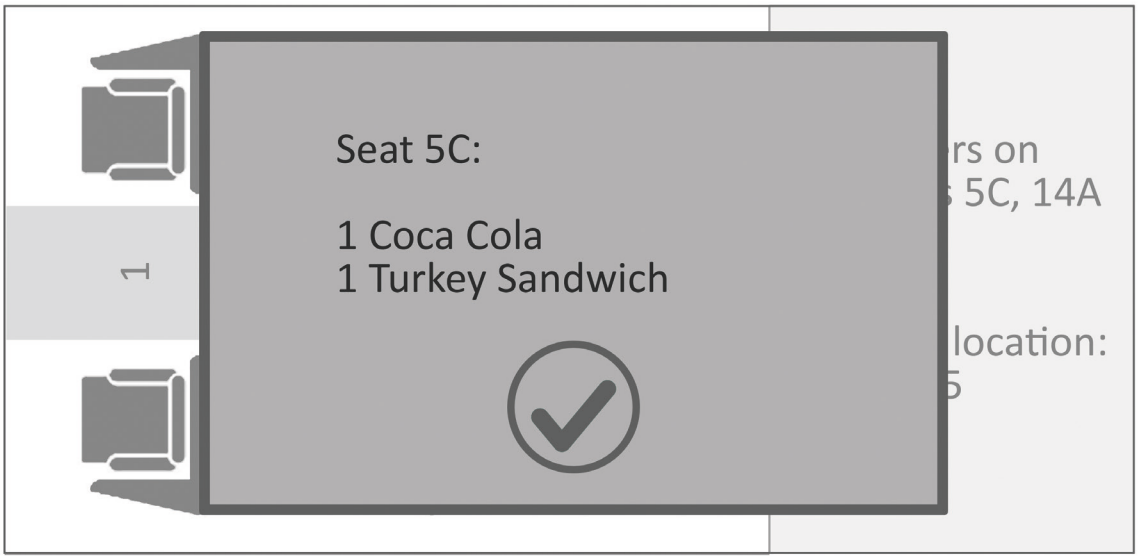

Figure 3.7: User interface when arriving at a passenger who made an order

3.4 DESIGN OF THE SMARTWATCH

The screen

The screen of the designed smartwatch has a size of 7.5cm x 4,5cm. In *figure 3.8* the screen is shown in its original size. The size of the letters is chosen to be 14pt and additionally, the displayed text on the example screen in *figure 3.8* is shortened in comparison to *figure 3.2* on page 83. This ensures that the text can be read more easily.

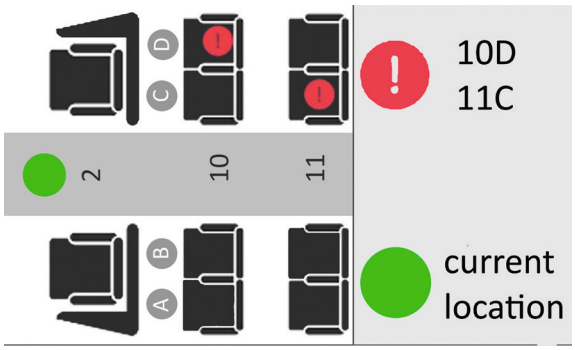

Figure 3.8: Screen in original size

First sketches

In the beginning, sketches have been made in order to choose the main style of the smartwatch. These sketches are shown in *figure 3.9*. The chosen style is the smartwatch in the bottom right corner. Since the smartwatch has a bigger screen than usual watches and smartwatches, the bottom side of this smartwatch is slightly curved in order to adapt to the form of the wearer's wrist. In this way, the smartwatch has a comfortable fit. Moreover, the wristband is relatively wide so that the screen cannot move.

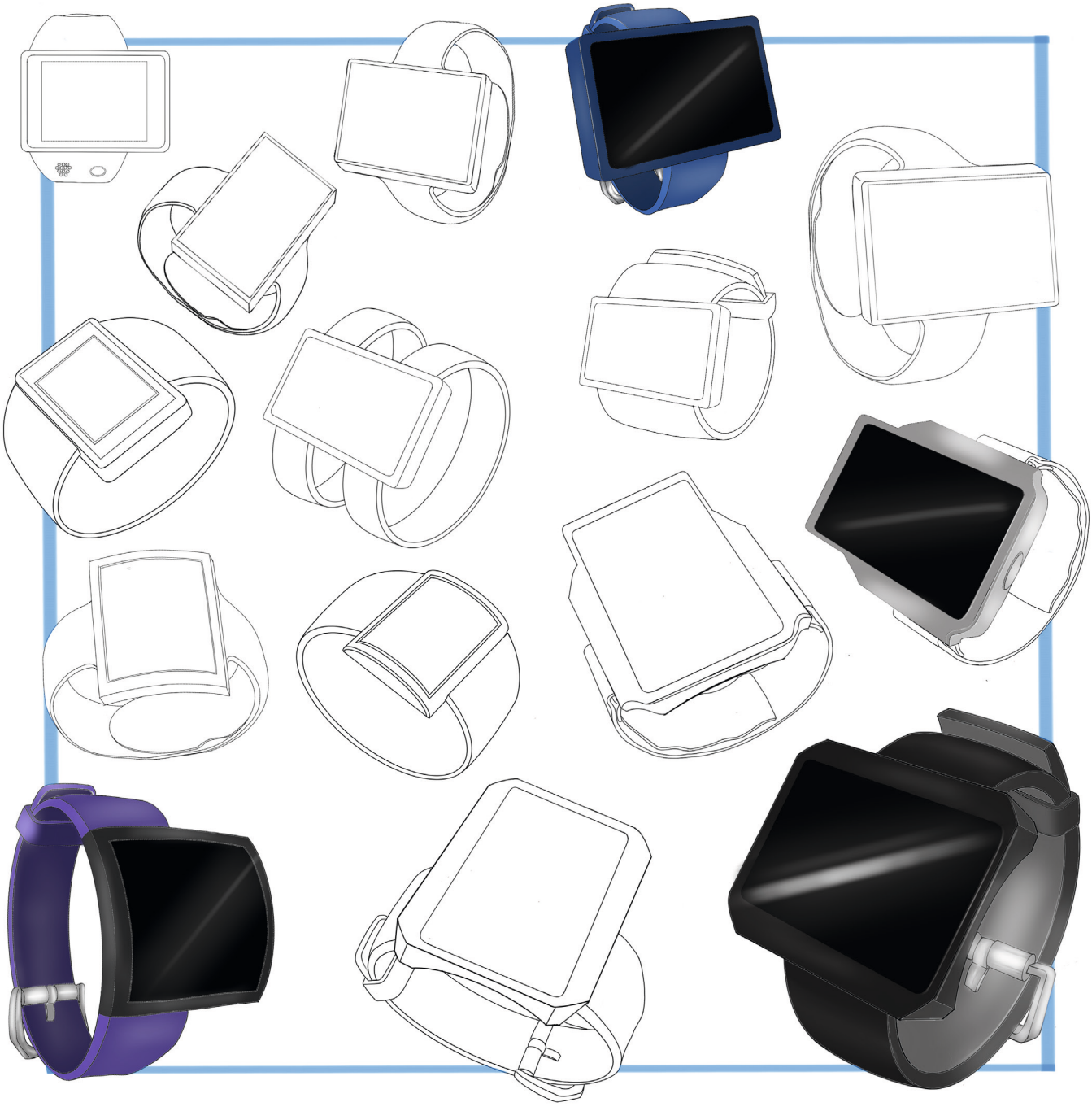

Figure 3.9: First sketches

3.2 FUNCTIONS OF THE SMARTWATCH

Detail sketches

After the main style was chosen, some details have been added to the smartwatch. The detail sketches are shown in *figure 3.10*.
The smartwatch only has one main button, just like a smartphone, which navigates the user back to the main menu. The rest of the navigation is done by using the touchscreen.

The wristband is adjustable so that it is universal for every wrist size. On grounds of hygiene, the material of the wristband should be a kind of rubber. Rubber can be easily cleaned in comparison to, for example, textiles or leather.

The color is chosen to be a dark grey; this color is neutral and fits to the uniform of every airline. Moreover, to ensure that also left-handed flight attendants can use the device, the screen can be rotated like on a smartphone. The flight attendant only needs to choose the button *rotate* from the device's setup menu.

Figure 3.10: Detail sketches

Final Design

The final design of the smartwatch is shown in *figure 3.11*.

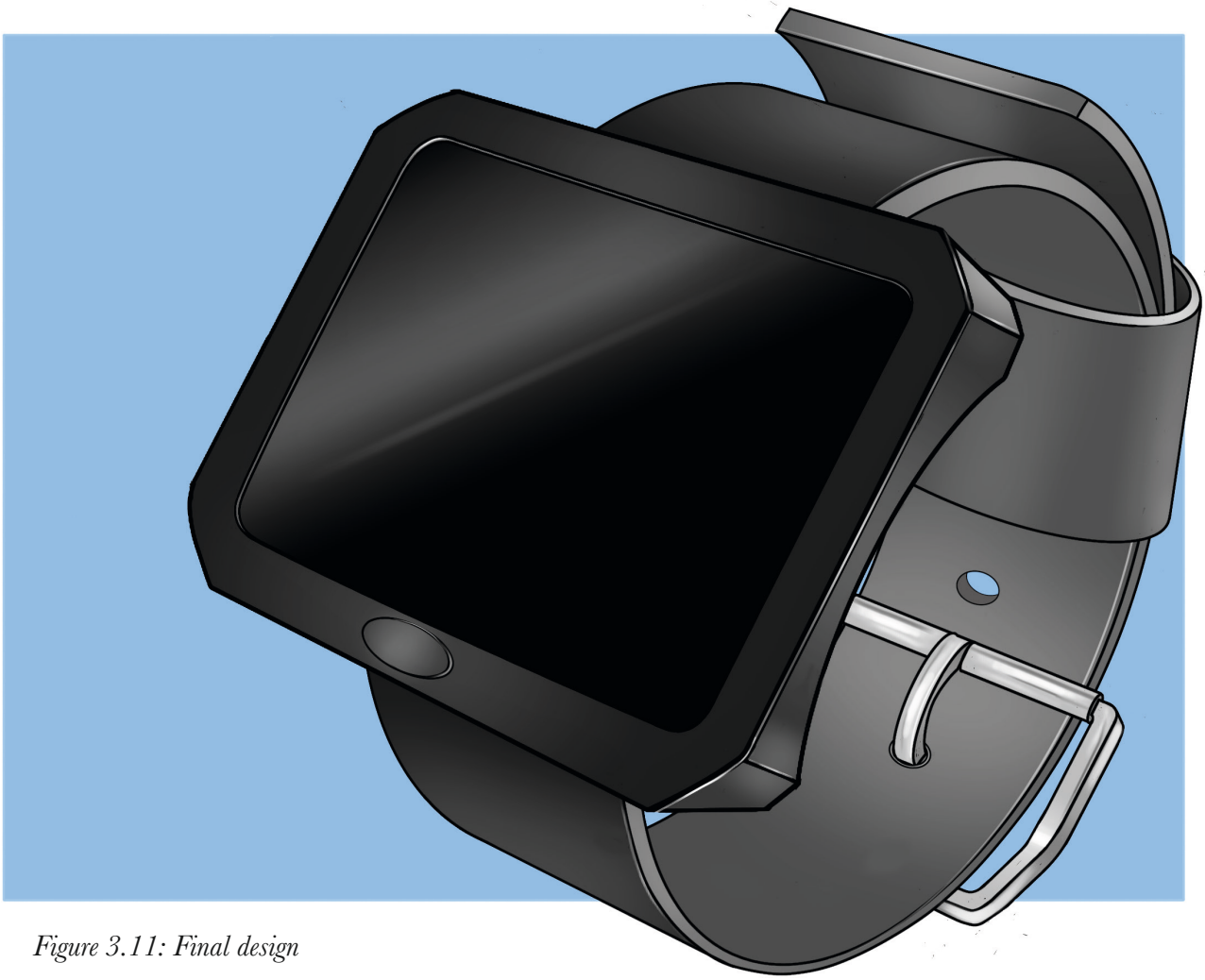

Figure 3.11: Final design

3.5 CONCLUSION AND RECOMMENDATIONS

3.5.1 CONCLUSION

The functions of the device

The aim of the bachelor assignment was to create a wearable for use in an aircraft cabin, offering valuable functionalities to the user. A wearable can be defined as a computing device worn on the body. The assignment was done for the aerospace equipment developer *Zodiac Aerospace*. The company focuses on niche markets and wants to develop products which 'rapidly acquire a leading position' *(De Beco, 2016)*. The market of wearables for use in an aircraft cabin definitely is a niche market in which the company can acquire a leading position with the designed product.

The product is a smartwatch for use for the cabin crew. By making use of the device, some procedures on board can be done more efficiently. These include checking if the seat belts are fastened and the bins are closed, the replacement of items which are lacking in a certain trolley, providing information on workshops and emergency cases, and serving orders to the passengers.

By integrating sensors into the seat belts and bins, the system is able to automatically inform the flight attendants when a passenger is not wearing his seat belt or a bin is still open. In this way, the flight attendants can immediately see which seats and bins need to be checked, so they do not need to check every single seat and bin. Moreover, currently, when a passenger is sleeping and turbulences arise, they need to be waked if their seat belt is hidden under a blanket in order to check if the passenger wears it. This can be avoided by this function.

When an item is lacking in a certain trolley it needs to be replaced. Currently, flight attendants need to ask their colleagues, who might be in another aisle, whether they still have the lacking item, or they need to look themselves where they can replace it. The designed smartwatch helps to make this procedure more time efficient and less stressful for the flight attendant by offering an application called *stock inspection*. When an item is missing, the flight attendant can look up if and where the item is still available.

In case a flight attendant cannot remember the needed instructions in, for instance, an emergency, the device provides information on the flight, workshops and various emergency cases. This function is just to be sure that in any case, the right instructions are followed.

The last procedure that is improved is the serving of orders. Presently, every passenger is asked if he would like to order something, or when orders are made via a user interface, the flight attendants need to remember which passenger ordered which item. The designed device provides flight attendants with information on that someone made an order, so that they can check on a screen in the galley which orders need to be prepared, and the smartwatch also informs the flight attendants when they arrive at the seat of a passenger who made an order and tell which item he ordered. Hence, the procedure is more

time efficient and convenient for both, the passengers as well as the flight attendants.

The design of the device

The design of the smartwatch is simple and functional. The screen is bigger than those of other smartwatches on the market. In this way, text displayed on the device's screen can be read more easily. In order to ensure that the smartwatch has a comfortable fit despite the relative big screen, the wristband is wider than usual.

Additionally, the bottom side of the smartwatch is slightly curved to adapt to the form of the user's wrist. Moreover, the size of the wristband can be adjusted so that the device is universal. Another important aspect during the design process was to design the product in such a way that the wearers as well as the people who get in contact with them feel comfortable.

Since the device is worn on the wrist and the passengers recognize when and how the device is used, in opposition to smart glasses, it is not daunting for them.

The business case

Of course, the company's goal is to earn money with the product. This can be done by selling or leasing the smartwatch to airlines. The device is interesting for the airlines since it helps to improve the passenger experience and it also makes the work of the flight attendants more convenient. The device is better suited than for example, smart glasses, since a smartwatch is socially more accepted and more comfortable to wear for the user. Additionally, the smartwatch is exactly adapted to the intended use and to the system of the *Connected cabin*, explained in *appendix F* on page 126, if it is used in combination with this platform.

3.5.2 RECOMMENDATIONS

Interviews

Three flight attendants as well as three pilots have been interviewed for this bachelor assignment. As it has been mentioned before, the amount of interviewed flight attendants and pilots has been chosen in order to gain insight into the whole scope of duties and also their personal opinions which should not contradict.

The questions about the personal opinion of the staff could have been asked to a larger amount of people because other people might have different struggles or opinions on what should be improved. Since there was limited time for the assignment, the interviews were not conducted with a large amount of people. Also, additionally to the interviews, it would have been very useful to observe the cabin crew while they are working. Considering the circumstances of the assignment, observations on an aircraft were not possible, but to gain more insight into potentials for new functionalities of the wearable device, observations could be made in the future.

Survey

The survey that has been conducted with potential passengers had 100 respondents since the platform *survio.com* limits the amount of respondents on 100 when a free account is used. Also, considering the limited time for the assignment, it would have taken too much time to conduct the survey with more people. However, to get more accurate results, the survey could have

3.5 CONCLUSION AND RECOMMENDATIONS

been conducted with a larger amount of potential passengers and also in different regions, since answers might differ between people with another ethnical background.

Functions

In the future, additional functionalities could be added to the device. For instance, the functionality of a real-time translator to make the communication with passengers easier could be added. Next to the possible functions mentioned in this thesis, solutions for new functionalities could be created. In order to get inspired, more interviews as well as observations could be made, as mentioned above.
Moreover, in a usual cabin, the designed smartwatch only checks on not fastened seat belts and open bins, but it could also check whether the seats are in the right position and the tables are folded away. For this, it would be necessary to do research on suited sensors and the costs for integrating the sensors into the seats.

Tests

To ensure that the flight attendants are pleased with the functionalities and the manner of handling of the device, user tests should be executed. For this, a prototype would be needed. Moreover, passengers could also be asked how they experience the service when flight attendants are using the device.

Manufacturing

Before the smartwatch can be manufactured, a material and the production technique must be chosen. Additionally, it must be checked on which supplier is going to deliver the materials and what the estimated costs are.

APPENDIX

APPENDIX A – INTERVIEW
QUESTIONS AND ANSWERS PILOTS

1. What is the common process of activities before and after the flight as well as during the flight?

Pilot A:
There are a lot of activities! But in short: I get into the aircraft and look at the technical status of the aircraft. You have a book in which it is listed what you have to do. Then I set the buttons properly and program the navigation of the computer.

Pilot B:
At first, the flight needs to be prepared: the route has to be chosen, the weather has to be checked, it has to be checked if there are any building lots at the airports and the mileage has to be calculated.
Then, there is the briefing with the cabin crew and afterwards we all go on board. On the aircraft, I insert necessary parameters like the route and flying altitude, the weight, weather and so on. At the same time, the other pilot runs around the aircraft and checks whether everything is working.
Then we take off and during the flight you use the autopilot. The air controllers give some instructions and you have to control the autopilot. You only have about ten buttons to control the autopilot, so most of the time the system works automatically. When the aircraft lands, the passengers get out of the aircraft and the flight is documented.

Pilot C:
Before the flight: In the beginning you meet the crew in the crew room. The pilots check the weather; look at the status of the aircraft and the route and have the briefing with the cabin crew about the upcoming flight. Afterwards we all go to the aircraft. One of the pilots goes around the aircraft and checks if anything is broken. The other pilot goes to the cockpit to prepare the aircraft for the flight. If it is needed to fuel the aircraft it is done at that moment and then the baggage is loaded into the aircraft.

During the flight: In general the aircraft flies automatically for about 99% of the time. Only the start and the landing are done manually. The rest of the time, the pilot only inserts parameters into the system about what the aircraft should do. The air controllers accompany you the whole time and might change the route.

Also, every half an hour fuel checks are done to check whether if it is in accordance with the calculations made beforehand. Furthermore, a so called flight log is filled in. The flight log is needed to document when the aircraft flies over which point and which frequency was needed to communicate with the air controllers. Nowadays as a pilot you mainly only have to manage the aircraft because of the many automatic systems.
After the flight: After the passengers left the aircraft it is time for the administration.

It is documented at which time the aircraft started and landed, the status of the aircraft, how much fuel had been used and such things.
When you finished the administration, the last checklists are done and then you leave the aircraft or you have to fly again, then one pilot again goes around the aircraft and checks if everything is fine and the other one programs the system.

2. How are the security checks done? Do you use checklists for

this or do you also use technical gadgets?

Pilot A:
A ground engineer checks the technical status as, for instance, the oil level and writes it down. The aircraft continuously checks every system and maps this on a screen. When something is broken, I am not allowed to repair it by myself but someone else does it. The only thing I can do is to reset the systems. Thus, everything has to work or it needs to be documented that something does not work and also does not need to work.

Pilot B:
The technical status of the aircraft is checked and when something is broken only an engineer with a corresponding license is allowed to repair it. I can only reset things and also it is only allowed to reset something when the aircraft is still on the ground. The system checks itself if it is broken or not and quite often the system gives error messages. Then, the pilot needs to verify the error and the system suggests a proceeding how to repair the error. Nevertheless, most of the times the error messages are wrong and there is no error.

Pilot C:
There is a procedure in the manuals about what you have to do. If you like, you can use it, but everyone knows it by heart.

3. Does an aircraft fly automatically?

Pilot A:
When everything is working, I manually steer the aircraft to the airstrip and also rise it manually. Then, the autopilot is switched on. The autopilot accelerates and steers the aircraft, similar to a cruise control and lane assist in a car. The autopilot is not intelligent; it does only do what you tell him to do. Depending on the type of the aircraft, more or less things work automatically like, for example, the regulation of the cabin pressure and of the temperature.

4. Do you have to insert new data during the flight?

Pilot A:
Most data is inserted beforehand. But when there are short-time changes, it is possible to insert new data. It is possible to use the autopilot in different ways: you can set to fly the whole route you programmed in the beginning, or you can set to maintain a certain direction, or you only set to keep the upside up.

Pilot B:
Normally that is not necessary. Short term changes mean a lot of stress for the pilot. So, it is possible but as I said, usually there is no need to change the parameters.

5. How long is a pilot allowed to fly?

Pilot A:
Per day you work for a maximum of 13 hours with ground time. So usually it is about 11.5 hours of flying. There are also regulations per week, month and year.

Pilot B:
That depends on the time of the day and how many flights you have per day. During the day you usually fly at least 12 hours and during the

night it is about 10 hours. When you have more than one flight per day, the total time shortens.

Pilot C:
That depends on a lot of different things. The maximum working time is 13 hours. But if you have more than one flight, the total working time reduces. Pilots do not really have a break, but when you fly long distances there might be three pilots on board and then you also have some time to rest. In Europe that is never the case.

6. How long is a pilot allowed to sleep and when?

Pilot A:
When you are ready with working for 13 hours, you can sleep. Or if there are three pilots, you can sleep when it is your turn for a break. But there are only three pilots on very long flights that are longer than 10 hours.

Pilot B:
With every shift there comes a certain time you need to rest. The resting time needs to be at least as long as the shift. So in that time you can rest and of course also sleep. Usually, pilots do not sleep on board. This only happens on very long flights when three pilots are present.

7. Where do pilots sleep and is it hard to get used to sleep on an aircraft?

Pilot A:
When you are sleeping on the aircraft, you sleep in a small cabin. I never sleep on an aircraft since I only fly short distances but most people can sleep on an aircraft.

Pilot C:
I only fly within Europe, so I have never slept on board. I cannot tell you how this is.

8. Do you stay in contact with control check points the whole time during a flight?

Pilot B:
Yes, during the whole flight the contact between the cockpit and the air controllers at the check points is hold. There are many different radiofrequencies, so you often switch to another air controller.

9. What are some positive aspects about the work as pilot?

Pilot A:
The work as pilot is very interesting, diversified and challenging. Additionally, you see a lot of the world.

Pilot B:
When you have finished your shift, you are really ready. I mean you cannot take your work home as it often happens at other jobs. And considering other employees who get about the same salary, pilots have to work less. Furthermore, I like that I meet so many new people.

Pilot C:
There are a lot of positive aspects when you work as pilot. You travel a lot, you have an ama-

zing view out of the cockpit, and of course also the salary is great.

10. What are some negative aspects about the work as pilot?

Pilot A:
You always have to work when other people have vacation and also the shift times are often very bad. Usually, I have to get up at four o'clock.

Pilot B:
You are away very often, so the job is really not suited for everyone.

Pilot C:
The high costs to become a pilot are a great burden to me. I had to pay about €180,000. Other negative aspects are that you are under a high working pressure, sometimes you are really stressed, that you have a lot of responsibility and you can get bored during a flight.

11. With which activities are you or your colleagues struggling?

Pilot A:
Often, it is not clear if everyone is already on board or not. Normally, it turns out fine, but when the ground handling is not that good, it is not clear right away.

Pilot B:
When you switch on the aircraft, additionally every single system needs to be switched on separately. Normally you would expect that when the main system is switched on, all of the systems will switch on automatically. So this really is a struggle of mine.

Pilot C:
The only aspect I can think about is that quite something goes wrong with the ground staff. Fuel that takes too long so that we have delay, stairs that are driven against the aircraft and something like that. Also there often is a language barrier so that you cannot communicate properly with the ground staff.

12. Are jet lags a great problem? Are there some strategies to avoid a jet lag or to overcome a jet lag quickly?

Pilot A:
Since I only do short distance flight, I had never a problem with jet lags.

Pilot B:
I only fly short distances, thus I have no problems with jet lags.

13. Are there some aspects that could or even should be improved?

Pilot A:
KLM especially focuses on the customer's experience and customer's appreciation. It could focus more on the employees.

Pilot B:
I do not have a good connection to the airline I work for, but this is more a personality problem of mine. Another aspect that could be improved might be to invent autonomous flying. By

this I mean that also the air controllers can send commands to the aircraft. This way it would be possible that only one pilot needs to be on board which would be more economical.

Pilot C:
The working and resting time could definitely be improved. In the past it was way more flexible but now we have to work at a maximum! Moreover, 'Pay to fly' should be disposed. 'Pay to fly' means that you have to pay for you pilot schooling. And also I work as freelancer and I have to pay for my lunches and coffee. I think that pilots should not be freelancers, so this should also be disposed.

14. Do sometimes communication problems occur between the cabin crew and the pilot?
a. If yes:
Why do these communication problems occur?

Pilot A:
Sometimes there occur a few communication problems. The reason for this is that the door between the cockpit and the cabin needs to be closed as much as possible. So you talk with each other via a telephone and sometimes it is not clear what the one at the other end of the phone means.

Pilot B:
Usually, such problems do not occur. You can simply communicate via a telephone and when it is the case that the cabin crew has a problem that might be important for the cockpit crew or the other way around, the crews try to stay in contact with each other.

Pilot C:
We frequently have communication workshops and we also have communication rules. Therefore there are usually not any problems.

APPENDIX B – INTERVIEW
QUESTIONS AND ANSWERS FLIGHT ATTENDANTS

1. What is the common process of activities before and after the flight as well as during the flight?

Flight attendant A:
Long distance flight:
At the airport the cabin crew meets with the pilot for a briefing. During the briefing, the positions within the aircraft cabin are distributed. That means everyone is assigned to a door on board. Also, the service tasks are distributed, thus who distributes food and drinks. Furthermore, the captain asks if everyone is fit enough to fly and if there have been medical incidents earlier. Then, he tells the predicted time of arrival and the total time of the flight.

Within the aircraft the security check is done and after that the boarding begins, that means that the passengers get on board.
During a long-distance flight, the first task is to distribute drinks. Also, the ovens for the meals are heated. When the meals are ready, they will be distributed to the guests. On each side one flight attendant hands out the meals while on the other side another flight attendant hands out drinks. When the guests are ready, everything will be collected and brought to the galley, the kitchen on an aircraft. Afterwards, the passengers are asked if they would like to buy something else, this is also referred to as on-board sales.

Next, the purser or purserette, the senior flight attendant, determines the guard and pause times for everyone. A part of the crew has the first guarding shift and the other part has pause time in which it is possible to rest. During the guard shift, the flight attendants prepare trolleys with drinks and check every half an hour if anyone needs something. Moreover, the toilets are checked; they are not cleaned but it will, for instance, be checked if someone smokes in there. After the first half of the guarding time, the shifts are switched and the part of the crew who had the guarding shift can rest and the other way around.
The flight attendants who have the second guard shift have to prepare the meals at the end of their shift.

After the guard time, the ‘saunas‘ are handed out. Saunas are warm towels that should help the passengers to get awake and to get fresh. Next, the meals and drinks are handed out and when the guests are finished, everything is again collected and brought to the galley.
Then the aircraft lands and the passengers get out of the aircraft. The flight attendants then check if no one has forgotten anything and if everyone left the aircraft.

Flight attendant B:
Short distance flight:
After the briefing we go on board and the first thing we do there is the security check based on the checklists. The checklist you get depends on your position within the aircraft. And then you basically check if everything is where it should be. After this, we prepare the trolleys with drinks and talk to the purser if all the meals and so on are in stock.
Then, the guests come on board and when the aircraft has started, we hand out food and drinks. Some flight attendants are in the business class and when they are finished they help in the economy class.
When the passengers are finished, everything is collected and the on-board selling is made.
Before the landing starts, we control if the passengers are wearing a safety belt and then of

APPENDIX B – INTERVIEW
QUESTIONS AND ANSWERS FLIGHT ATTENDANTS

course the aircraft lands. Then the de-boarding starts and we check if the aircraft is empty.

2. How are the security checks done? Do you use checklists for this or do you also use technical gadgets?

Flight attendant A:
For the security check checklists are used on which every part of the aircraft is listed that needs to be controlled. We do not use any technical gadgets for this. The checks are only done visually or by opening and searching the bins and the security equipment.

3. To what do you have to pay attention during the security checks?

Flight attendant A:
It is checked if everything is where it should be, for instance, if every seat has the required security equipment. Also, we have to search the bins for hidden objects. We also control a sample of life vests to check whether there are hidden object in them or not. The toilets give quite a lot of opportunities to hide object, so they also have to be controlled.

4. The meals that are handed out during the flight, do they only have to be warmed or are some meals also prepared on board?

Flight attendant A:
For the economy class passengers the meals are just warmed. The meals are prepared beforehand and are put into the oven for 30 minutes. For the first class passengers, the meals are usually just warmed too, but sometimes it happens that, for instance, an egg is cooked for breakfast.

5. How do you keep track of the food orders especially regarding some kinds of diets like vegetarianism and veganism?

Flight attendant A:
When a passenger has special requests for his meals, then he can order a so called *special meal* beforehand. On the package of the meal it is noted what kind of meal that is, for instance, lactose free, and which passenger ordered that meal as well as the corresponding seat number.

6. How many flight attendants are on board during a flight?

Flight attendant A:
That depends on the size of the aircraft. In an A380 there are 19 flight attendants.

7. How long is a flight attendant allowed to sleep and when?

Flight attendant A:
You are allowed to sleep during your break, thus when one part of the crew has its guard shift and the rest of the crew has a break. How long this break is depends on the total guarding time,

thus on the length of the flight. Usually, you have a maximum of three hours to sleep.

8. Where do you sleep on an aircraft and is it hard to get used to sleep on board?

Flight attendant A:
As flight attendant, you sleep in small cabins. I do not have any problems to sleep on board and I never had. I also do not know anyone who cannot sleep well in the aircraft. The job as flight attendant is very hard, so when you get some rest, you immediately fall asleep.

Flight attendant B:
As a flight attendant you sleep in a cabin in the crew rest. In the beginning I was struggling to fall asleep because the aircraft is droning very loud and there are always people moving. They turn around in their beds or someone goes to the toilet or a child is crying or running around in the aircraft cabin. Now it is a little better, I always take my smartphone with me and watch a series until I fall asleep.

Flight attendant C:
I never had a problem to sleep on an aircraft; I always fall asleep very quickly.

9. What are some positive aspects about the work as flight attendant?

Flight attendant A:
For me it is a great advantage that I travel a lot and that I get to see the world. I have also seen countries that I would never have expected to see. Additionally, you meet a lot of new people and make new friends all over the world. Also, the interaction with the passengers is fun. Since I work for Lufthansa, I also like that there are a lot of options to work part-time. This way you can do something else next to your job as flight attendant.

Flight attendant B:
You really see a lot of the world and you meet so many new people, not only colleagues but also passengers of course. I learned a lot about other cultures and relative to your actual work time, you have quite a lot of free time. Moreover, I like the working atmosphere.

Flight attendant C:
There are a lot of aspects that I like but also do not like about the work as flight attendant. For example, it can be great that you always work in a new team, because this way you get to meet a lot of new people and I think that is interesting. Also you travel to many different countries and you get to know other cultures.
What I really like about my work is that I work with people and that I do not have a 'normal 'life routine.

10. What are some negative aspects about the work as flight attendant?

Flight attendant A:
When you work full time, you really fly a lot and that can be very exhausting. When you had a long distance flight, you have quite a lot free time in the country you travelled to, but me for example, I want to see as much as possible in that country. So, I get up quite early and I run around the whole day. On a continuing basis this lifestyle is very stressful and physically demanding. Additionally, when you are a little sick in the beginning of a flight, you will be very

ill at the end of the flight. Because of the dry air in the aircraft, an illness will only made worse.
Another aspect that I do not like about the work as flight attendant, when you work full time, is that you often are away from home.

Flight attendant B:
I do not like the night flights, they are exhausting! Also when you are working full time, you are away from home a lot. Additionally, you are quite inflexible with your working times. When there is, for instance, a case of death in your family, you still have to work and cannot get free. You are only allowed to take a day off when you direct family members like your children or your husband die.

Another thing I do not like about working as a flight attendant is the superficiality of the conversations but also some people. Because you nearly always fly with people you never met before, the conversations are not really deep. And therefore people often like to talk about their appearances. Which lipstick do you use? Is the hair well colored and do the fingernails look pretty? That can be very annoying sometimes.

Flight attendant C:
As I said before, a lot of aspects that I like about my job are also aspects that I do not like sometimes. I said that it can be great that you always work in a new team, but this can also be very annoying, because when you get along with another person very well you are unlikely to work with that person again. And there is also a chance that you have to work with people that you do not get along with very well. Also, it can be annoying that you travel that much, because in every country they speak another language and you can just not communicate in your mother tongue. Moreover, I do not like night flights since they are really exhausting. And jet lags are also annoying; it took quite some time until I *figure*d out how to handle them.

11. With which activities are you or your colleagues struggling?

Flight attendant A:
In general the service flows quite smoothly when there are not any freshmen in the crew. When I started to work as flight attendant I struggled with uncommon situations like for example when a passenger fainted or someone brought a dangerous substance on board. After a while you get used to that kind of situations and flight attendants have a lot of seminars that prepare well for such situations.

Flight attendant B:
The process of the assignment of the positions is always a problem. The flight attendants that already work for a long time are the so called seniors. Based on their seniority, they have a lot of freedom of choice. They can pick their favorite position and task. So some flight attendants rest on their seniority and refuse to work on a position other than their favorite one or to do some tasks they do not like. That is not fair to the rest of the crew.
Another aspect is that we are not allowed to lift the bags of the passengers. But it is hard to refuse this, because usually you want to help. So there are sometimes discussions about that within the crew.

Flight attendant C:
Flight attendants usually try to avoid arguments. Therefore they always just accept stress and rude behavior. Afterwards you usually feel worse, when you always try to be friendly. When

a major difficulty occurs, the purser has to deal with it and needs to settle the dispute.

Furthermore, there is always a discussion if we help guests to store their bags or not. We are not allowed to do that, but some do this anyway.
Another aspect that can easily go wrong is the storing of the trolleys. You have to turn over two knobs to lock them; the same holds for the box of the trolleys. When a knob is forgotten, the trolley is not locked properly and can still move. Also, it is annoying to count how many normal meals and *special meals* are on board and where the passenger sits who ordered a *special meal*.

Furthermore, it often happens that someone is not concentrated because of tiredness and/ or a jet lag. Then some little accidents might happen like, for instance, that someone burns himself while making coffee or preparing the meals.

Additionally some flight attendants promise the passengers something that another flight attendant would never promise and often these promises cannot be met.

12. Are jet lags a great problem? Are there some strategies to avoid a jet lag or to overcome a jet lag quickly?

Flight attendant A:
There are not really effective strategies to avoid a jet lag. The only thing I know is to try not to look at watches so that you forget about the 'normal' time or to just keep that 'normal' time, so that when you come home you will not have a jet lag. Of course, the latter only works when you do not want to see the country you travelled to. Some of my colleagues also take sleeping pills to get into the new time rhythm. I would not recommend this, because you really harm your 'inner clock' with that and it is also not good for your body.

Flight attendant B:
Jet lags are not really a big problem for me. The first day of arrival can sometimes be difficult, but usually when I arrive in the daytime, I nap about two hours in the afternoon and the next day everything is fine. When I arrive in the late afternoon or evening I do not nap but go to bed early and that does also work for me.

Flight attendant C:
Jet lags are not that easy to handle. Now, I *figure*d out when I have to sleep to not have such a bad jet lag, but it took me some time to *figure* that out. I have special sleep patterns for each flight. When I follow them, I usually do not have a bad jet lag. But I know other flight attendant who struggles a lot with jet lags. Some of them take sleeping pills to handle their sleeping problems.

13. In what way does the service in the business class differ from the service in the economy class?

Flight attendant A:
For passengers in the business class there is an extra tea/coffee and dessert service that you do not have in the economy class. Also, the meals and drinks are brought to the guests by hand instead by using a trolley.

Flight attendant C:
In the business class, one flight attendant is responsible for about 15 guests and the guests are

addressed with their names. So, it is way more personal than in the economy class.

14. Do you often have to deal with passengers who have fear of flying?

Flight attendant A:
Yes, that happens now and then. Sometimes I notice that a guest is as white as chalk and that he is totally cramped. Then I go to him and try to settle him by calmly talking to him. This helps a little in most cases. Once in a while a passenger also comes up to the flight attendants and asks for help. I would say that there are a few passengers with fear of flying on every fifth flight.

Flight attendant B:
That happens a lot, yes! Once, during a workshop, we were told that about 50%-80% of the passengers are afraid of flying. You can note this fear at about 10% of the passengers. These people start crying or throwing up or something like that.

Flight attendant C:
There is always someone on board who has fear of flying. And about every tenth flight there is someone on board who has heavy reactions as a result of this fear of flying. Heavy reactions are for example that the passenger starts to cry a lot, that he throws up, that he faints or that he has a panic attack.

15. How often are there medical emergencies on board and how do you handle them?

Flight attendant A:
There are quite frequent medical emergencies on board. Really often passengers faint – there is at least one passenger per flight who faints. Sometimes I fly to Houston and there is a famous lung clinic, so then there are a few passengers with lung problems on board and we have to be extra attentive. Every year flight attendants have to do a first aid workshop to refresh their skills. Thus in most cases we are prepared very well.

Flight attendant B:
During a flight there is at least one 'medical' on board. 'Medicals' are people who have a medical incident. Very often passengers faint or throw up but sometimes something worse happens. I once had a guest on board who had an epileptic seizure and once a pregnant woman was on board who threw up and fainted. Normally, there is at least one doctor on board who can help in such a case. If there is no one on board, we can call an emergency hotline. Then a doctor tells us what exactly we have to do and which route we can take to get to the nearest hospital.

Flight attendant C:
I have never been on a flight where something really bad happened. Emergencies happen a lot, so I know that someday I will experience such a

case. What I experience a lot is that people faint or throw up.

16. Are there some aspects that could or even should be improved?

Flight attendant A:
There is definitely something that could be improved but right now I cannot think of something. When you work with the right team, everything works just fine.

Flight attendant B:
There are a lot of things! First, the hardware of the aircrafts should be improved. Often there is something broken and either it is irreparable or it will be broken for months before it is repaired. Often there are guests that ask for the on-board showers or wellness area but these things never work. Also, the Wi-Fi does not work properly most of the time.

Another aspect are the staff savings. You are constantly under pressure and it is more likely that you do something wrong.
Moreover, in the business class one flight attendant is responsible for 16 guests, that is very stressful and also it is less pleasant to work alone instead of in a team.
The teams are that big that one purser cannot manage everything, so this should really be improved.
And the last thing is the inflexibility you have when you work as flight attendant.

Flight attendant C:
The procedures are quite optimized, so it does not happen very often that something goes wrong. But there are often technical outages and it takes a lot of time until it is repaired. Thus, the hardware should be improved; for instance, it would be great if there was working Wi-Fi on board. The ground processes are not that good, therefore the passengers are often discontented when they come on board and start complaining. Furthermore, the layovers should be longer so that you have more time to rest and to see the cities you travelled to. Another aspect that could be improved is that during the briefing emergency cases should be treated a bit more; now it is at least 70% only about the service.

17. Is there something that bothers you about passengers?

Flight attendant A:
Mostly everything is fine but once in a while there are some passengers who are discontented with everything and who complain the whole time. I have also had situations in which a passenger got very angry. In the beginning of my career, such a situation frightened me. But we frequently have workshops about how to handle such a situation and the more often you are confronted with a situation like that, the more you get used to it. We learn how we can defend ourselves even against very tall or heavy persons and also how to bond them.

Flight attendant B:
I do not like when a passenger is bugged and gets personal or sometimes even abusive and threatening. Another aspect that annoys me is when a guest asks me to tell the guest in the row in front of him to adjust the back of the seat. I

always tell such a guest that he can just ask the other guest himself.

Flight attendant C:
Some guests complain about everything or they want some extra service, for instance, some want to eat earlier and when they do not get their meal they sometimes go into the galley to take it themselves. Also I do not like when people stand in the aisle and want to chat when it is late at night. Even though I am awake, I would like to rest a little at that time.

18. How good is the communication between the pilot and the flight attendants?

Flight attendant A:
The communication with the pilot is usually good. When there is something important to tell the pilot or the other way around, the crew stays in contact with the pilot to keep up to date.

Flight attendant B:
Normally, the communication between the pilot and the flight attendants works fine. Sometimes there are some misunderstandings because the cockpit crew talks in terms of technical facts and the cabin crew does not understand it and focuses on the service. But there are also workshops for the cabin and cockpit crew to improve this.

Flight attendant C:
Sometimes there are some disagreements between the cockpit crew and the cabin crew concerning the procedures. Also there are sometimes some misunderstandings because both crews are focused and trained on different aspects. The cockpit crew is very straightforward and factual while the cabin crew is focused on the service.

19. Does the cabin crew communicate with the pilot orally or via, for instance, a headset or something similar?

Flight attendant A:
At every door on board there is a telephone with which you can call the cockpit crew. And as I said before, when there is something important happening, the cabin crew talks with the pilot about every five minutes.

20. And what about the communication between the flight attendants and the passengers? How good is it?

Flight attendant A:
The communication between the flight attendants and the passengers is generally also good. Sometimes there is a passenger that complains about everything, but you get used to it.

Flight attendant B:
The communication with the passengers is mostly good. The guests are usually very polite and I think that the interaction with the passengers is more personal and individual than it is at other airlines.

Flight attendant C:
Usually, the communication between the flight attendants and the passengers is good. Drunken guests can be problematic because they can be very rude or sexist. Also, language barriers are sometimes a problem. Some guests do not speak another language besides their mother tongue

and we cannot communicate with them in English or German.

21. Do sometimes communication problems occur within the cabin crew?
a. If yes:
Why do these communication problems occur?

Flight attendant A:
That depends on the people who you are working with. Everyone is assigned to one of the doors on board, so that small teams are formed. Thus, you do not work with 18 other flight attendants but you work in groups of five or six. In such a small group, the communication is way easier than in a large group.

Flight attendant B:
Usually there are no problems but every now and then there are crew members that really do not get along. The purser is then responsible to settle the dispute.

Flight attendant C:
Since all flight attendants are trained to be able to solve conflicts and to get along with nearly everyone, there mostly are not any conflicts. In some team constellations the team members do not communicate enough and then it might happen that someone makes a mistake or that there are misunderstandings.

22. Do the cabin crew members communicate with each other orally or by using the telephones at the doors?

Flight attendant A:
Within the compartments you communicate orally. Normally you do not communicate with the other teams but if you do so, you use the telephone.

APPENDIX C – QUESTIONNAIRE:
PASSENGERS' EXPERIENCES

Introduction for respondents:
For my bachelor assignment I am designing a wearable for use in an aircraft cabin. A wearable is a computing device worn on the body such as *Google Glass* or smartwatches. To gain insight into the needs of potential passengers, I formulated a few questions concerning the habits and struggles during a flight. Thank you in advance for participating in this survey!

1. Age:
   12-20 years: 24 (24.5%)
   21-30 years: 40 (40.8%)
   31-40 years: 11 (11.2%)
   41-49 years: 12 (12.2%)
   53-58 years: 9 (9.2%)
   62-64 years: 4 (4.1%)
   Not specified: 2

2. Gender:
   Female: 58
   Male: 40
   Not specified: 2

3. Have you ever flown before?
   Yes: 96%
   No: 4%

   a. If you answered with 'yes': Do you fly on a regular basis?
   Yes: 39.6%
   No: 60.4%
   b. If you answered with 'no': Why have you never flown before?

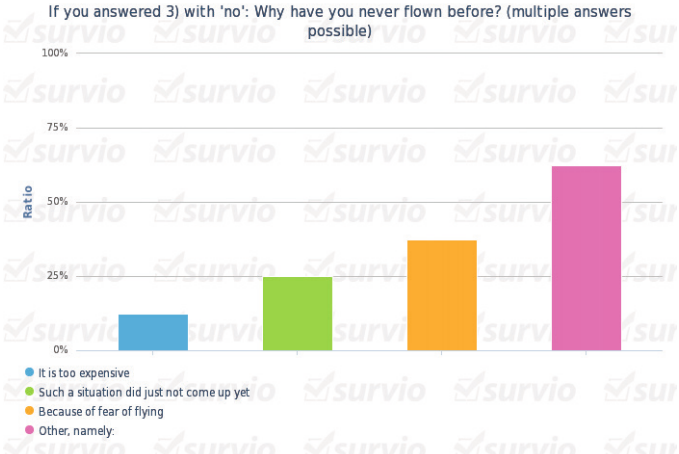

Figure A1: Reasons not to fly

Others are:

- Prefer to go on holiday by car or train
- Pollution

4. Do you feel nervous about flying?

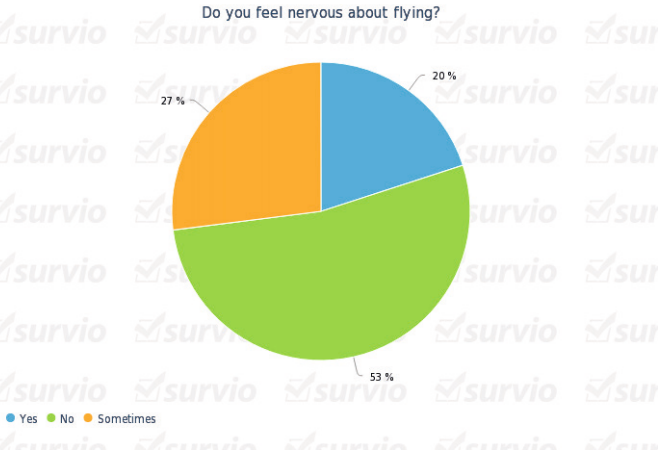

Figure A2: Nervousness about flying

a. If you answered with 'yes' or 'sometimes': Do you consider this nervousness as fear of flying?

Yes: 51%

No: 49%

b. If you answered with 'yes' or 'sometimes': Why do you feel nervous about flying?

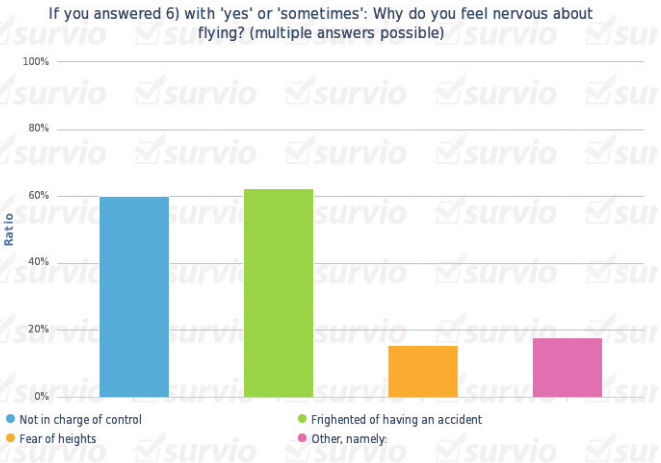

Figure A3: Reasons for nervousness about flying

Others are:
- New things are scary
- Time pressure
- Bird flying in the engine

c. If you answered with 'yes' or 'sometimes': How do you usually handle this situation?
- Try avoiding to think about having an accident
- Remind oneself of the statistics how unlikely it is to have an accident
- Distract oneself by doing something like listening to music

Information for respondents:
The following questions are meant for people who have flown before. If you have never flown before, you can finish this survey.

5. What do you like about flying?
Answers in descending order of how many people mentioned that aspect:
- One can get to the desired destination very fast
- The view is great
- Feeling of freedom
- The technology of an aircraft is fascinating
- Flying is cheap
- The food

6. What do you not like about flying?
Answers in descending order of how many people mentioned that aspect:
- Not enough space
- Waiting time before the flight
- Fear of having an accident
- It is often cold in the aircraft cabin
- Feeling the turbulences of the machine and not knowing what is going on
- It is very noisy
- Not being in charge of control
- The dry air
- The food
- Fear of highjacking

7. What do you usually do during a flight?

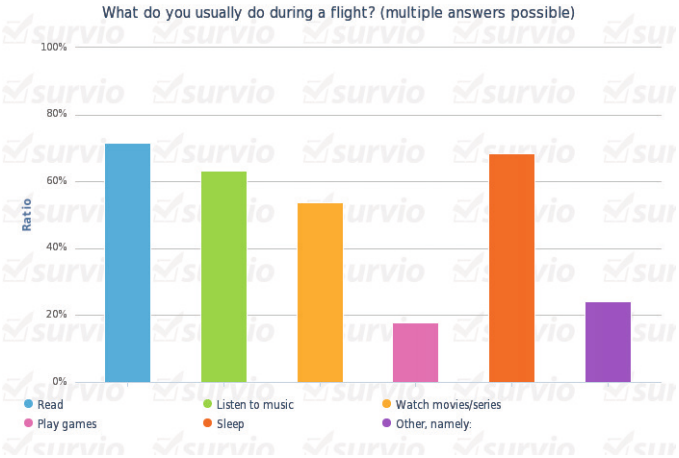

Figure A4: Activities during a flight

Others are:

- Looking out of the window
- Talk to neighbours
- Work

8. Are you pleased with the communication between the flight attendants and the passengers?
   Yes: 94.8%
   No: 5.2%

a. If you answered with 'no': Why are you not pleased with the communication between the flight attendants and the passengers?

- There barely is any communication
- In the economy class you do not feel appreciated
- I would like to hear that the flight is going well

9. Are you pleased with the communication between the pilot and the passengers?
   Yes: 82.1%
   No: 17.9%

a. If you answered with 'no': Why are you not pleased with the communication between the pilot and the passengers?

- There barely is any communication
- I would like to get updates on the flight: how long does it take, is everything working etc.
- I would like to know who is flying the plane; an introduction of the pilot would be great

10. Which aspects on an aircraft could/should be improved?

(e.g. the offers on entertainment, the service etc.)
Answers in descending order of how many people mentioned that aspect:

- The seats should be more comfortable and also bigger
- The offers on entertainment
- There should be Wi-Fi on an aircraft
- More information on the flight
  - The pilot could speak to the passengers more often so one can feel more related to him (eg.: giving the passengers information like 'dear passengers, I recommend to take a look out of the window because we are passing the alps now' or general information like 'the plane will fly an eight to leave the airport')
- More explanations in the physics of the aircraft (How does the machine work?)
- Better ways to get in contact with the service staff
- The air in the aircraft cabin
- Free water (in bottles)
- There should be more privacy
- The toilets should be cleaned more often

11. Can you sleep well on an aircraft?
Yes: 46.9%
No: 53.1%

a. If you answered with 'no': Do you have problems to fall asleep or to stay asleep?
i. Fall asleep: 34.6%
ii. Stay asleep: 13.5%
iii. Both : 51.9%

b. If you answered with 'no': Why do you have problems to fall/stay asleep?

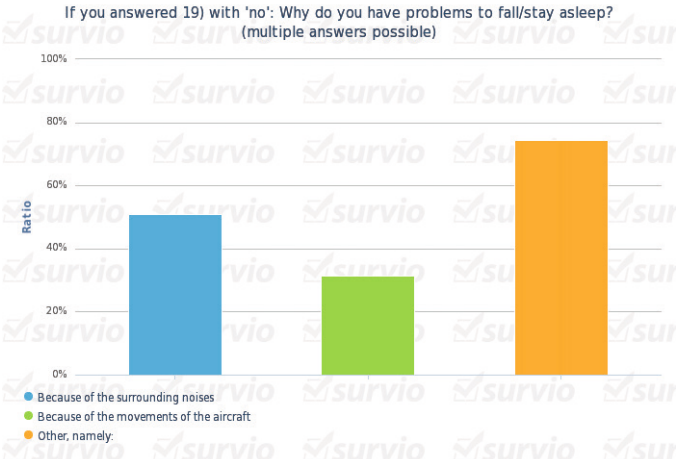

Figure A1: Reasons for not flying

Others are:

- Uncomfortable
- Too little space
- Bad air quality
- Because of being constantly afraid (cannot relax)

12. Do you feel safe in an aircraft cabin?

Yes:77.1%

No: 22.9%

a. If you answered with 'yes': Why do you feel safe?

- It is statistically the most safe way to travel
- Because I trust the technology
- Because of the crew and the instructions

b. If you answered with 'no': Why do you not feel safe?

- Not in charge of control
- Because if there is an emergency, one is likely to die
- Feeling bad due to being that high in the air
- Feeling uncomfortable because there are so many people in so little space

APPENDIX D - MIND MAPS

Mind map for a device to overcome nervousness about flyin

Based on the potential functionalities of a wearable that helps to overcome nervousness a flying, a mind map has been made with possible solutions. The mind map helped to brainstorr solutions. It is shown in *figure A6*.

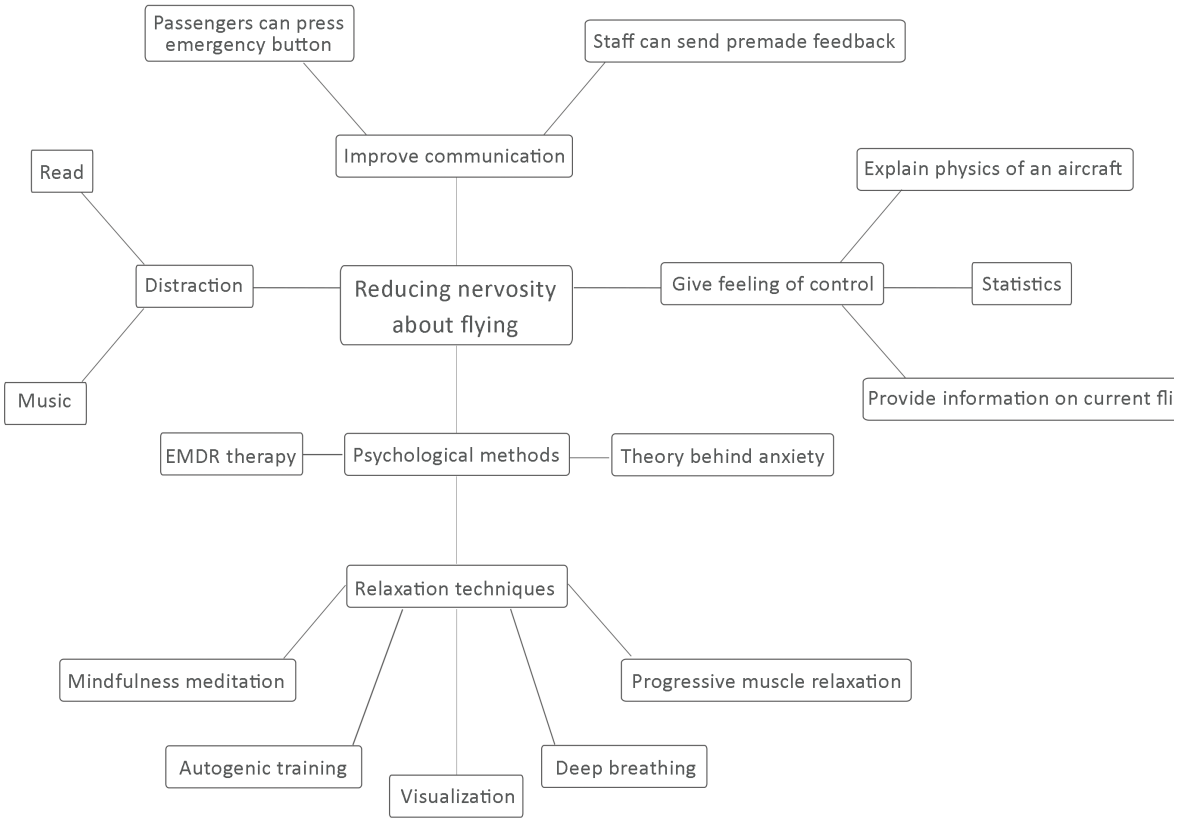

Figure A6: Mind map: device to overcome nervousness about flying

Mind map for a device for improving sleeping behavior

Based on the potential functionalities of a wearable that improves the sleeping behavior on an aircraft, a mind map has been made with possible solutions. This mind map is shown in *figure A7*.

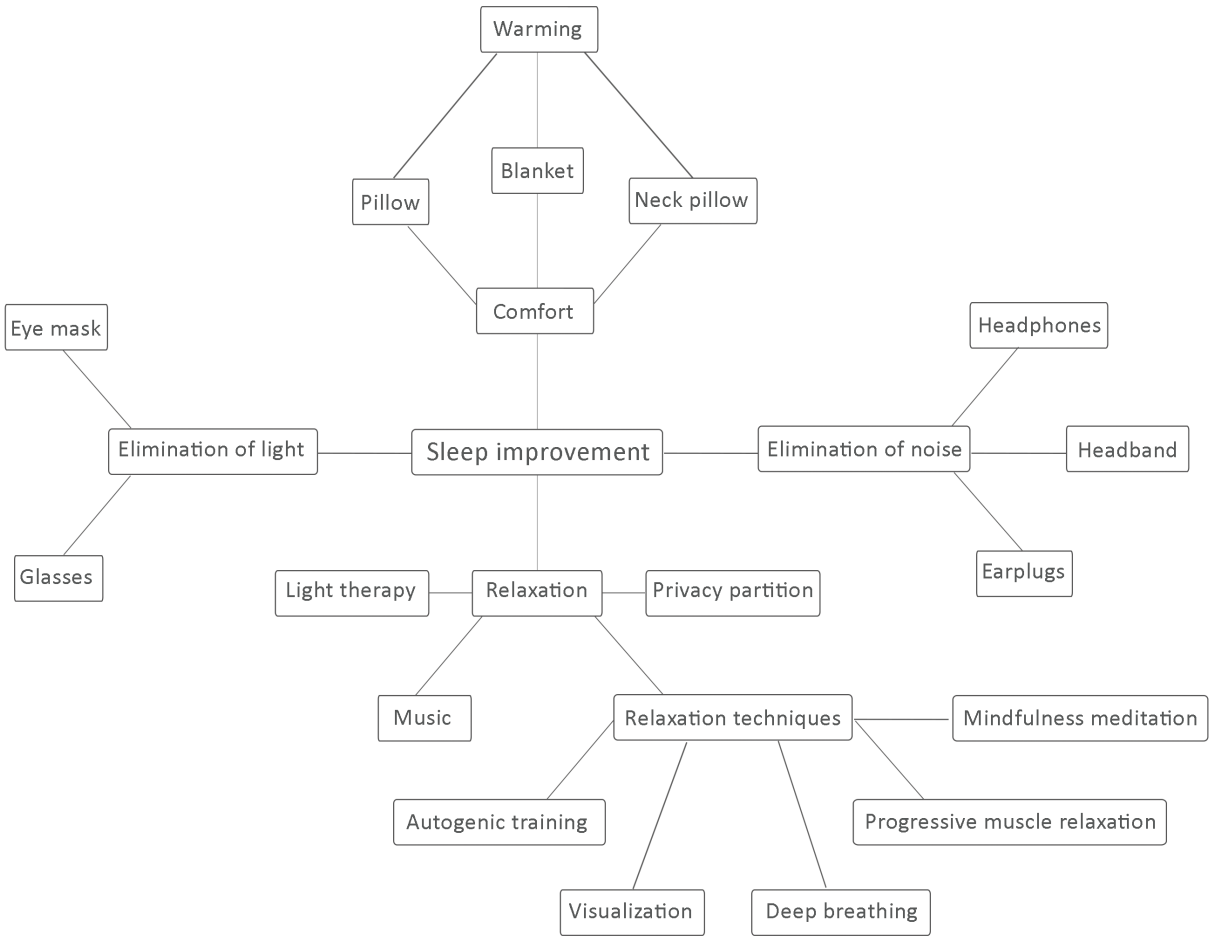

Figure A7: Mind map for a device for improving sleeping behavior

APPENDIX D - MIND MAPS

Mind map for a wearable for the cabin crew

Based on the potential functionalities of a wearable for the cabin crew, a mind map has been made with possible solutions. This mind map is shown in *figure A8*.

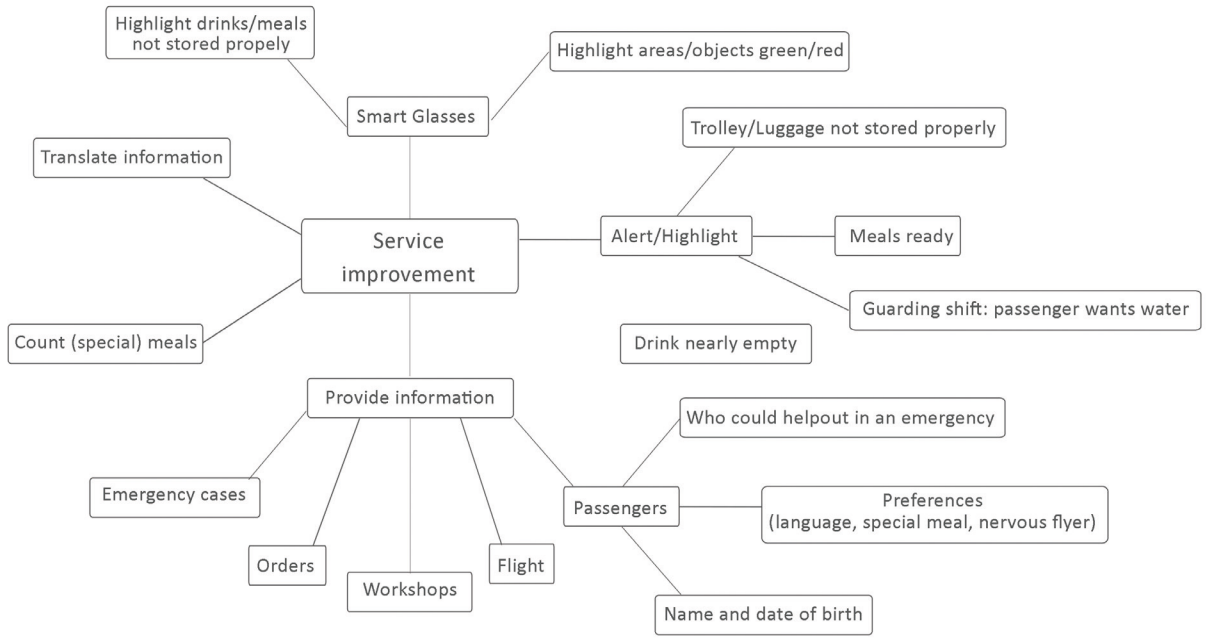

Figure A8: Mind map for a wearable for the cabin crew

APPENDIX E – COSTS OF REED SWITCH AND HALL EFFECT SENSORS

REED SWITCH SENSORS

Average costs: €4.23
Products on which the data is based on:

MK 03

Average costs for 100 pieces: €2.18
MK03-1A66B-500W *(Mouser Electronics, 2017)*
- Costs for 100 pieces = € 2.37

MK03-1A66B-500W *(Premier Farnell Ltd, 2017)*
- Costs for 100 pieces = € 2.43

MK03-1A66B-500W *(Digi-Key Electronics, 2017)*
- Costs > 5000 pieces) = € 1.02
- Costs for 100 pieces = € 1.33

MK03-1A66C-500W *(Digi-Key Electronics, 2017)*
- Costs > 5000 pieces) = € 1.02
- Costs for 100 pieces = € 1.33

MK03-1A66D-500W *(Mouser Electronics, 2017)*
- Costs for 100 pieces = € 1.37 €

MK03-1A66E-500W *(Premier Farnell Ltd, 2017)*
- Costs > 500 pieces) = € 3.00
- Costs for 100 pieces = € 3.22

MK03-1C90C-500W *(Onlinecomponents.com, 2017)*
- Costs > 10000 pieces) = € 2.94
- Costs for 100 pieces = € 3.22

MK 14

Average costs for 100 pieces: €5.15
MK14-1A66B-200W *(Mouser Electronics, 2017)*
- Costs >2500 pieces = € 4.29
- Costs for 100 pieces = € 5.16

MK14-1A66B-500W *(Digi-Key Electronics, 2017)*
- Costs >1000 pieces = € 4.68
- Costs for 100 pieces = € 5.44

MK14-1A66B-500W *(Mouser Electronics, 2017)*
- Costs >2500 pieces = € 4.53
- Costs for 100 pieces = €5.44

MK14-1A66B-500W *(Onlinecomponents.com, 2017)*
- Costs >10.000 pieces = € 2.35
- Costs for 100 pieces = € 3.56

APPENDIX E – COSTS OF REED SWITCH AND HALL EFFECT SENSORS

MK14-1A66C-200W *(Mouser Electronics, 2017)*
- Costs >2500 pieces = € 4.30
- Costs for 100 pieces = € 5.17

MK14-1A66C-500W *(Mouser Electronics, 2017)*
- Costs >2500 pieces = € 4.53
- Costs for 100 pieces = € 5.54

MK14-1B90E-500W *(Mouser Electronics, 2017)*
- Costs > 1000 pieces) = € 6.31
- Costs for 100 pieces = € 7.24

MK14-1C90E-500W *(Onlinecomponents.com, 2017)*
- Costs for 100 pieces = € 9,05

MK 18

Average costs for 100 pieces: €6.38

MK18-B-100W *(Digi-Key Electronics, 2017)*
- Costs for 100 pieces = € 7.06

MK18-B-190W *(Onlinecomponents.com, 2017)*
- Costs for 100 pieces = € 3,32

MK18-B-300W *(Digi-Key Electronics, 2017)*
- Costs >1000 pieces = € 4.81
- Costs for 100 pieces = € 5.59

MK18-C-100W *(Mouser Electronics, 2017)*
- Costs >2500 pieces = € 4.08
- Costs for 100 pieces = € 4.91

MK18U-BV14749 *(Onlinecomponents.com, 2017)*
- Costs >500 pieces = € 9.88
- Costs for 100 pieces = € 11,01

MK20/1

Average costs for 100 pieces: €3.22

MK20/1-B-100W *(Premier Farnell Ltd, 2017)*
- Costs > 500 pieces) = € 2.19
- Costs for 100 pieces = € 2.73

MK20/1-B-100W *(Onlinecomponents.com, 2017)*
- Costs >10.000 pieces = € 2,17
- Costs for 100 pieces = € 2,95

MK20/1-C-100W *(Mouser Electronics, 2017)*
- Costs >2500 pieces = € 3.74
- Costs for 100 pieces = € 4.50

MK20/1-C-100W *(Premier Farnell Ltd, 2017)*
- Costs >500 pieces = € 2.15
- Costs for 100 pieces = € 2.68

HALL EFFECT SENSORS

Average costs: USD 4.16 = €3.71
Products on which the data is based on *(TTI, Inc., 2017)*:
Honeywell 2SS52M

- Costs >5000 pieces = USD 1.63
- Costs for 100 pieces = USD 1.91

Honeywell 1GT101DC

- Costs >250 pieces = USD 21.097
- Costs for 100 pieces = USD 21.98

Honeywell 2SS52M-S

- Costs >5000 pieces = USD 1.776
- Costs for 100 pieces = USD 2.075

Honeywell SS41

- Costs >25.000 pieces = USD 0.49
- Costs for 100 pieces = USD 0.68

Optek / TT Electronics OHN3120U

- Costs >500 pieces = USD 1.728
- Costs for 100 pieces = USD 1.942

Optek / TT Electronics OHS3177U

- Costs >1000 pieces = USD 1.439
- Costs for 100 pieces = USD 1.712

Honeywell SS494B

- Costs >5000 pieces = USD 1.1528
- Costs for 100 pieces = USD 1.4822

Optek / TT Electronics

- Costs >250 pieces = USD 1.484
- Costs for 100 pieces = USD 1.532

APPENDIX F - CONNECTED CABIN (CONFIDENTIAL)

Zodiac Aerospace is currently working on a new product line, the connected cabin platform *ICONNZ*. The platform's goal is to improve a variety of processes on board for a more efficient service and an improved passenger experience. The basic principle of *ICCONZ* is that any object in the cabin is able to exchange data with the server through the *Zodiac Access Points*. Not only can data be exchanged within the cabin but there could also be a data exchange between the aircraft and the ground, for instance, to coordinate with the supply chain to stock and service the aircraft. In the following, an entire flight is described to show what the functions of the *ICONNZ* are (*Zodiac Aerospace, 2017)*.

Smart trolleys

Before the airplane takes off, the aircraft needs to be stocked. For this, the galley is loaded with the trolleys. The items in the trolleys are automatically registered so that the system knows how many items are on board. Additionally, each trolley has sensors for monitoring food safety indicators such as the temperature in the trolley. The data of the trolley shows if anything unusual has happened. When, for example, the temperature in a certain trolley exceeded the food safety threshold, the data is sent to the catering supervisor. The supervisor then decides if any further action is required and sends a notification to the galley to inform the flight attendants (*Zodiac Aerospace, 2017)*.

Security checks

The next step is the security check that is executed by the flight attendants. *ICONNZ* helps to execute the security checks more efficiently by detecting whether an item is missing. When, for instance, a life vest is missing at a certain seat, the system will inform the flight attendant who can then place the missing item at the corresponding seat. *ICONNZ* also assists the flight attendants by checking for tray tables, armrests, backrest positions, cabin blinds and seatbelts before takeoff. When a seat is not in the right position, the flight attendants are informed on the screen in the galley and can address the corresponding passenger to follow the instructions properly. In *figure A9* the screen can be seen showing which seats need to be checked (*Zodiac Aerospace*, 2017).

Hospitality

Another functionality of the platform is to enable the passengers to make their own food orders aboard. On a screen in front of the passengers, that is equipped with the so called *hospitality* application, the passengers can choose what they would like to eat. The application does also take care of the galley stock. Thus, when a meal is not in stock anymore, it is automatically ordered from another galley (*Zodiac Aerospace*, *2017)*.

Maintenance

ICONNZ also helps with the maintenance of the products in the cabin. The status of each product can be accessed from a screen in the galley. There, the flight attendants can 'manage, monitor and review all cabin-related issues' (*Zodiac Aerospace, 2017)*. In the connected aircraft cabin, the performance data from various sources is collected. The *product health* application notes changes in the data and based on historical usage data it might determine 'a critical condition and recommends an exchange' (*Zodiac Aerospace*, *2017)*. In case a product should be exchanged, a request for replacement is sent to the airline (*Zodiac Aerospace, 2017)*.

Lighting system

Another new function of *ICONNZ* is the advanced lighting system that can be controlled from a control panel. With this system many different light settings can be made. Mood light can be set or also sunrise program can be activated so that the passengers are gently wakened (*Zodiac Aerospace, 2017)*.

Data documentation

After the aircraft has landed relevant data, that has been collected during vthe flight, is uploaded to a server and is made available to relevant partners. This data 'contains performance metrics, hospitality data and records from the product health application' (*Zodiac Aerospace, 2017)*.

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